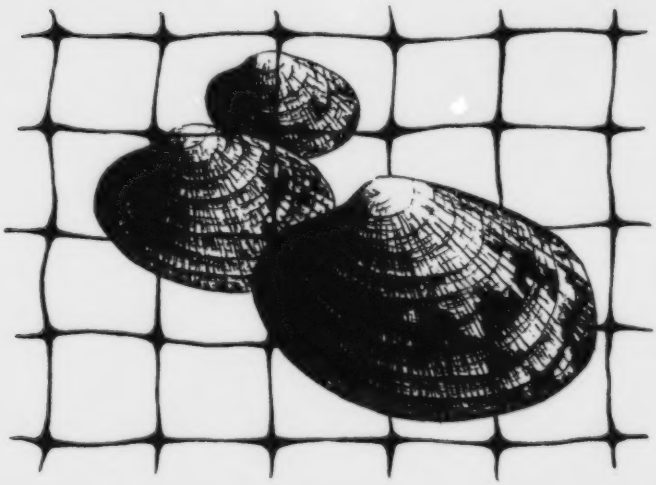
BRITISH COLUMBIA
MANILA CLAM CULTURE WORKSHOP

TRANSCRIBED PROCEEDINGS

Held at
Parksville, B.C.

November 16 - 18, 1988



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BRITISH COLUMBIA
MANILA CLAM CULTURE WORKSHOP

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Letter from the Ministry

The Ministry of Agriculture and Fisheries is the provincial lead agency for aquaculture growth and development in British Columbia. As such, we have recognized the need to evaluate the status of both the wild clam fishing industry and clam culture technology.

To answer this need, the Manila Clam Culture Workshop was held. The response that was shown by the aquaculture industry at this workshop, along with the presentations and discussions, reconfirm our belief that although a cultured clam product is a distinct possibility in British Columbia, we must first establish sound techniques and guidelines for foreshore use that ensure the progressive development of a clam culture industry. These developments must also be done in direct liaison with the existing aquaculture industry in British Columbia.

The Ministry of Agriculture and Fisheries may be contacted for additional information pertaining to clam culture topics such as permitting, siting or technology. We shall strive to aid the continued growth and development of the aquaculture industry in British Columbia.

Mr. Jim Anderson, Acting Director

Aquaculture and Commercial Fisheries Branch
British Columbia Ministry of Agriculture and Fisheries

Editors Preface

As promised the transcribed proceedings of the Manila Clam Culture Workshop have been edited and compiled into a comprehensive publication. The proceedings are fairly verbatim and each speaker has edited their presentation to ensure its accuracy. We believe that this publication fills an immediate need for pertinent information on Manila clam culture in British Columbia. This workshop and report are the result of the willingness of clam diggers, processors, culturists, government agencies and interested parties to share their expertise and views about the clam fishery, culture and their future in British Columbia. If this publication does nothing more than address the problems in the present wild clam fisheries and question the possibility of clam culture/enhancement, we as editors will feel that this publication was worth the effort. We hope that you find this document comprehensive in its coverage of all areas pertinent to clam fisheries and culture in British Columbia. If further information regarding this publication is required, please do not hesitate to contact us. Additional copies of the publication may be obtained, for a small publishing fee, from the Aquaculture Association of British Columbia (tel. 604-758-2922). Thank you for your time and patience,

Mr. Tom Broadley
Mr. Lorne Clayton
Mr. Bill Roland

Acknowledgements

A publication of this size requires the thankless work of quite a few individuals, not the least of which are the participants, speakers and organizers. We would like to take this opportunity to thank everyone who was affiliated with this workshop and subsequent publication.

Funding for the workshop was made available from the Ministry of Agriculture and Fisheries. Mr. Jim Anderson and Dr. Al Castledine, of the Aquaculture and Commercial Fisheries Branch, were enthusiastic supporters of the workshop. The staff of the Island Hall, Parksville provided a hospitable setting for the workshop. The participants at the workshop were an informative and inquisitive audience. The speakers, who were the key to the success of this workshop, willingly shared their experience, knowledge and views and also put up with our editing demands and time deadlines. Mrs. Liane Miller taped and transcribed the entire proceedings of the workshop. Mr. James Cuell, Mr. Robert Cox and Mr. Ted Kuiper provided valuable material in the appendices. Mr. K.J. Albrecht drew the Manila clams and netting on the front cover.

To all of the people we express a large note of appreciation for their work and involvement in the 1988 Manila Clam Culture Workshop.

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WORKSHOP SUMMARY AND RECOMMENDATIONS

Mr. Tom Broadley and Mr. Lorne Clayton

SYNOPSIS OF THE PRESENT CLAM INDUSTRY IN BRITISH COLUMBIA

The high current market demand and, therefore, value of the Manila clam has resulted in a dramatic increase in fishing effort. As a result, the profile of the industry has changed, concentrating greater harvesting efforts on smaller areas and diminishing high quality standing crop. The large numbers of undersize and polluted clams appearing are evidence of this. Many beaches have been exploited to such a degree that both government agencies and industry are concerned that we may be in danger of over harvesting this common resource. In response the federal regulatory agency has developed and invoked conservation closures in specific areas in order to allow the natural clam populations to recover. However, these closures have only lead to further inconsistent and unpredictable clam landings in a market place that continues to escalate.

The Manila Clam Culture Workshop was staged in order to address this situation and to discuss alternatives such as clam enhancement and/or culture. This two day workshop entailed 33 presentations from a variety of speakers from British Columbia, Washington and California including industry members and government regulatory and development agencies. The theme of the workshop was to address the current and potential problems of the present wild clam fishery and evaluate the possibility for the enhancement/culture of the Manila clam in British Columbia.

PROBLEM IDENTIFICATION

During this workshop it was possible, through discussions with participants and attendees, to identify those problems which negatively affect the current industry infrastructure. The following problems were identified as the most pertinent:

Current Fishery Situation

- a conflict exists between the commercial and recreational fisheries which often results in seasonal harvest closure;
- current fishery policies and regulations are inadequate to deal with the continual changing composition of the harvesting community;
- some harvesters utilize inappropriate digging methods which may result in unacceptable juvenile mortalities;

- enforcement of minimum size limits by fisheries personnel is inconsistent and often focused on the processing rather than the fishing level of the clam industry;

- inadequacies in the current Personal Commercial Fishing Licence program have resulted in the inability to determine the number of transient harvesters and the volume of clam harvest by area;

- the inability to have controlled relaying of polluted stock for natural depuration underutilizes a significant portion of the harvestable clam stock;

- as a result of restrictive regulations, harvesters are unable to attempt enhancement of the natural fishery through any method (ie. moving undersize clams from high on the intertidal to a lower level) with the exception of abstinence of harvest and maintaining minimum harvest size limits;

- domestic and industrial pollution negatively impact upon the clam industry;

- personnel and monies are unavailable to adequately carry out testing for paralytic shellfish poisoning and sewage contamination;

- area openings and closures instituted to conserve populations have a negative impact on the market; and

- the lack of adequate constructive industry input into government policies and regulations related to resource management may impede industry development.

Current Enhancement/Culture Situation

- there is an absence of adequate definitions, policies and regulations which address the possibility of clam enhancement and/or culture in British Columbia;

- there are no policies which allow an intertidal common property resource to be under the control of a specific user group;

- there is not yet available the information required to adequately determine if the planting of clam seed on beaches and subsequent grow out technology is economically viable and fits in with any proposed definition of clam enhancement/culture;

- the current policy regarding clams on oyster leases is unclear and confusing to the industry;

- the practicality of clam and oyster polyculture has not been adequately addressed, especially with the clam grow out technology utilized in the United States;

- area conservation closures negatively affect clam culture operators by not allowing harvest at the discretion of the farmer;

- positive government policies and regulations which would promote the development of a clam enhancement/culture industry do not exist and it is unknown if they would be incorporated into the current clam fishery policy and regulation infrastructure;

- there are inadequate resources for the testing of paralytic shellfish poisoning, disease and sanitary shellfish water quality to allow optimal harvest of product from future enhancement/culture situations;

- there is an inability to procure new enhancement/culture tenures on known highly productive lands;

- prospective clam farmers cannot utilize investigative permits to test in situ clam culture potential of unknown productivity lands;

- it is illegal to be in the possession of wild undersized clams for beach reseeding (enhancement/culture) purposes; and

- there does not exist a good industry role model of self policing and diligent use in order to assist in the development of an appropriate government policy and regulation for clam enhancement/culture.

POSITIVE ASPECTS OF THE CURRENT MANILA CLAM SITUATION IN BRITISH COLUMBIA

As made clear at this workshop, it appears that the future of the current clam fishery is threatened and roadblocks deter the immediate development of a Manila clam enhancement/culture industry in British Columbia. There exists however, many positive attributes of the clam fishery and for the potential of Manila clam enhancement/culture in the province. They include:

- the current intertidal clam industry (all species) is the largest shellfish fishery in British Columbia valued in excess of $10,243,000 annually;

- the fishery is a renewable and non-polluting resource;
- clam enhancement/culture is a renewable and non-polluting industry;
- clam enhancement/culture is desirable for remote areas of the coast by diversifying coastal economies;
- large clam populations can be supported on the existing beaches in the province;
- clam growth to market size is achievable in two to four years;
- no wide spread or debilitating clam diseases are known;
- the technology for the development of a clam enhancement/culture industry is known and presently being utilized in Washington State;
- industry entrance can be gained with relatively low capital expenditure;
- a well developed clam processing infrastructure exists;
- strong and escalating markets exist worldwide for British Columbia Manila clams;
- Manila clam products are marketable year round;
- enhancement/culture can take place on large portions of existing shellfish tenures which will diversify product and financial risk to industry members; and
- an infrastructure of equipment suppliers and transport already exist within the province.

RECOMMENDATIONS

After an analysis of the workshop proceedings, and discussions with industry members and government officials, a series of recommendations have been developed. In order to maintain a healthy and viable Manila clam fishery and to promote the development of an economically and technically feasible clam enhancement/culture industry in British Columbia, the following recommendations are proposed:

Recommendations to Government

It is recommended that governments:

- in association with industry, develop regulations which realistically define clam enhancement/culture, the overall purpose of which is to significantly increase clam production over the existing wild capability, and incorporate these regulations into the existing policy and regulation infrastructure;

- define by how much and in what manner this increase in productivity must be undertaken;

- in association with industry, address changes to policy and regulations with respect to the development of an adequate Clam Fishing Licence for both commercial and sports fishermen, review beach closure policies and fishery enforcement regulations;

- be willing to alienate some select, public natural resources that are capable of supporting increased clam production through enhancement and/or culture that is consistent with their definition of these terms;

- assist industry to establish production and management plans for the planning and development of economically viable clam enhancement/culture consistent with the governments definition of enhancement/culture;

- provide adequate resources (monetary and personnel) with respect to the monitoring and testing of paralytic shellfish poisoning, disease and sanitary shellfish water quality which will support the development of a clam enhancement/culture industry in British Columbia;

- establish policies and regulations that encourage the utilization of natural and controlled depuration;

- support both enhancement/culture and economic studies in order to determine the long term viability of Manila clam enhancement/culture in British Columbia; and

- sponsor regular clam culture workshops to review current progress, assign research priorities and to assist in the planning and development of a clam culture industry.

Recommendations to Industry

It is recommended that industry members:

- form an association, or align with an existing one, which is self policing with respect to diligent use and quality control;

- carry out commercially applicable clam enhancement/culture

studies to determine the economic feasibility of the industry;

- work with governments in developing appropriate policy and regulations for the orderly development of a continually viable wild clam fishery and clam enhancement/culture industry in British Columbia;

- seek to secure the rights of ownership to clam populations on provincially controlled crown lands specifically designated for clam enhancement/culture purposes;

- develop a positive industry image by utilizing tenured areas diligently, honestly and productively;

- ensure high quality product that meets the demands of the market - not the harvester - and to carry out market research and product development; and

- provide accurate statistics to the monitoring bodies to assist in recording the progress in industry development.

It is strongly suggested that by addressing the above recommendations that we:

- may achieve the maximum harvest of clams either through the enhancement of the wild fishery or through the culture of the Manila clam;

- capture a substantial share of current and future market demands;

- reduce enforcement problems;

- achieve optimal yield production potential on existing shellfish tenures; and

- utilize and adopt the technology that has been developed in other parts of the world in order to create a stable and economically successful clam fishery and enhancement/culture operations in British Columbia.

INTRODUCTION

Mr. Lorne Clayton, IEC Collaborative Marine Research and Development Ltd.

There is considerable interest in the possibility of culturing the Manila clam in British Columbia. If the turn out at this workshop is an indication of the degree of interest, I suspect that many have underestimated the interest in this matter.

Culturing of clams is a new concept to British Columbians. There have been some attempts by industry to "manage" clam beds, usually by keeping other diggers away. True clam culture, however, could involve the seeding, protection and maintenance of a clam population until harvested. The definition of clam culture is unclear and will be discussed during the next few days.

We know that clams grow in British Columbia, and we understand, for the most part, where they grow. The harvesting, processing and marketing infrastructure for Manila clams is well developed. Some of the questions that require answering in B.C. Do we know the best areas to culture Manila clams? What is the best management strategy for culturing clams? The most important question - and at the moment the hardest one to answer - is it possible to culture clams profitably?

The purpose of this workshop is to address these issues and ask questions. If clam culture looks economically feasible then it will most likely proceed. We may, however, have to work diligently to overcome obstacles to develop an economically viable industry. We encourage you to listen to the speakers, ask pertinent questions and to contribute your own knowledge and experience. We also encourage you to make your views known to those in attendance who have the ability to encourage the development of Manila clam culture in British Columbia.

We felt that in order to address the issue of clam culture we must first understand the current clam fishery. There are very few people in British Columbia that can address this issue as well as our first speaker, Dr. Neil Bourne.

CLAM FISHERIES AND CULTURE IN BRITISH COLUMBIA

Dr. Neil Bourne, Department of Fisheries and Oceans

INTRODUCTION

I am pleased to be here to participate in this Manila Clam Culture Workshop. As many of you know, I have been connected with bivalves and clams for many years and I have always attempted to maintain a close association with industry to encourage the fullest utilization of our clam resources. I hope that what I have to say today will help us achieve this goal. I realize that I have been given the honour of being the lead off speaker and I presume I am supposed to introduce the subject and say something intelligent about it.

I have been asked to say a few words on species and populations of clams that can support commercially viable industries, the history of the spread of the Manila clam in British Columbia, and technical aspects of clam culture in British Columbia. Because of time constraints, my comments will be brief but hopefully to the point.

CLAM SPECIES

British Columbia has a rich molluscan fauna. Bernard (1970) conservatively estimated there were about 520 species of marine molluscs in British Columbia waters that included 180 species of bivalves. However, only 18 species have been or are used in commercial fisheries; nine species of clams, three species of oysters, four species of scallops and two species of mussels. A few other species may be used in the recreational fishery.

The nine clam species may conveniently be divided into those that occur predominantly in the intertidal area and those that occur predominantly in the subtidal area. Most species occur in both areas but fisheries are concentrated on either intertidal or subtidal stocks.

Species harvested in intertidal clam fisheries include: razor clam, Siliqua patula; and Manila, Tapes philippinarum. In addition occasional minor landings are made of cockles, Clinocardium nuttallii and soft-shell clams, Mya arenaria.

Species harvested in subtidal clam fisheries include: geoduck, Panope abrupta, and two species of horse clams, Tresus capax and T. nuttallii.

INTERTIDAL FISHERIES

Razor clams occur only on surf swept ocean beaches and there are few centers of population in British Columbia. The main center of the population is on beaches east of Masset in the northeast part of Graham Island in the Queen Charlotte Islands. Smaller centers of population are in the Long Beach area on the west coast of Vancouver Island and on the west side of Calvert Island.

The only commercial fishery is on populations at Masset although occasional minor landings were made in the Long Beach area. Harvesting is by hand digging although one attempt was made to harvest razor clams by a mechanical harvester. The fishery began at Masset in 1924 and has continued to the present time. Recently, landings have been under 100 tons annually because almost the entire catch was used for crab bait. In the last two years, attempts have been made to process razor clams for human consumption and landings have increased to 140 tons.

Subtidal populations exist but few attempts have been made to harvest them. One estimate in the late 1960's indicated an annual sustained harvest of 250 tons was possible from intertidal populations.

Butter clams occur throughout British Columbia from the lower third of the intertidal area to subtidal depths of 10 meters. They are most abundant in sheltered areas in mud, sand and gravel substrate.

Commercial fisheries have occurred throughout the Province but in recent years have been confined to the South Coast District because of PSP (paralytic shellfish poisoning), distance from markets and high processing costs. Harvest is by hand digging although attempts have been made to use mechanical harvesters. Butter clams were once the dominant species harvested in clam fisheries and were generally canned and used for making chowders. Recently, because of high processing costs and a change in the market, landings have been small. In 1987 they were only 69 tons.

Extensive butter clam resources exist in the Province that could support higher levels of harvest.

Littleneck clams occur on beaches throughout the Province and form a major part of the biomass of many beaches. They occur generally on sheltered beaches and in firmer substrate than where butter clams occur, mostly sand, gravel substrates. They are most abundant from the top of the lower third to the mid intertidal beach area.

Although littleneck clams occur throughout the Province, commercial harvest has been virtually confined to the South Coast District. Harvest is by hand digging although attempts have been made to use mechanical harvesters. Frequently littlenecks are harvested along with either butter or manila clams.

Landings of littleneck clams have ranged from 190-375 tons in recent years. Landings could be higher if stocks in the North Coast District were harvested.

Manila clams are an exotic that occur throughout the South Coast District and as far north as the Bella Bella area of central British Columbia. They occur in firm substrate, sand, gravel, and are most common at the mid intertidal beach area. Subtidal populations are unknown in British Columbia.

Harvest is almost entirely from the South Coast District and is by hand digging or raking although attempts have been made to use mechanical

harvesters.

Manila clams are now the main species harvested in commercial fisheries and in the last five years, landings have increased from 1,049 to 3,608 tons.

Cockles are not particularly abundant in any one locality in British Columbia and are usually found in muddy bottom. They have been landed incidentally with other species.

Soft-shell clams are widely used on the east coast of North America but have not been harvested to any extent in British Columbia. They generally occur in mud substrates high up in the intertidal area.

SUBTIDAL FISHERIES

Geoducks occur throughout British Columbia from the lower part of the intertidal area to subtidal depths of at least 20 meters, generally in a mud, gravel bottom.

A fishery of subtidal stocks began in Washington in 1971 and spread to British Columbia in 1976. Harvest is entirely from subtidal stocks and mechanical high powered water jets are used in the fishery.

Landings increased sharply when the fishery began but have remained fairly constant at about 5,000 tons in the last three years because of area quotas. Harvest is from both the South Coast and North Coast Districts.

Horse clams, both T. capax and T. nuttallii, occur throughout British Columbia from the lower third of the intertidal area to subtidal depths of 10 meters. T. capax generally occurs in mud, gravel substrates and T. nuttallii in sand substrates.

Both species were occasionally harvested in intertidal fisheries but landings were small and not recorded. In recent years, landings from subtidal populations have been made by geoduck divers after the geoduck quota has been met. Landings have ranged from 7-355 tons.

OTHER CLAM RESOURCES

Intertidal clam resources have been well studied and although detailed estimates of biomass have not been made, general levels of biomass are known.

Enquiries are frequently received about the abundance of subtidal clam resources, similar to those that occur off the east coast of North America which support large fisheries.

Extensive surveys were made to assess subtidal clam resources in 1960 and 1961 (Quayle 1961 and 1963) but it appears that none exist. There may be extensive geoduck resources at deeper depths which could sustain a larger fishery but this is unknown.

No surveys have been done to assess clam resources in the immediate subtidal region, i.e. from the 0 tide level to subtidal depths of 10 meters. Results of such surveys in Washington showed there were stocks of butter and littleneck clams in this area (Goodwin 1973). Certainly there are stocks of horse clams in this area in British Columbia and they are being harvested at the present time. It is doubtful if there are large populations of butter and littleneck clams in this region in British Columbia because of heavy predation but the problem warrants investigation.

Landings of intertidal clams could increase if stocks in the northern area could be harvested and there may be stocks of geoducks in deep water that could be harvested. However, populations are limited and harvest cannot rise indefinitely. Other methods to increase production must be examined, e.g. culture or enhancement.

MANILA CLAM DISTRIBUTION IN BRITISH COLUMBIA

Manila clams are an exotic that were accidentally imported into British Columbia with juvenile Pacific oysters, Crassostrea gigas. They were first recorded in Ladysmith Harbour in 1936 (Bourne 1979). It is interesting to note that they were first discovered in British Columbia even though much heavier importations of Pacific oyster seed were made into the Puget Sound area and Manila clams are common there now.

The spread of the Manila clam in British Columbia is well documented (Bourne 1982). In the early 1940's, it was the most common intertidal clam in Departure Bay (Neave 1949) and it spread quickly throughout the Strait of Georgia. Dissemination along the west coast of Vancouver Island probably started from introductions of juveniles accidentally imported into Barkley Sound along with Pacific oyster seed. By the late 1950's, they were found in Esperanza Inlet. It was thought that spread might be halted at Brooks Peninsula since it tends to be a biological barrier, however, in 1966 an extensive population was found in Quatsino Sound.

The spread north of the Seymour Narrows-Yuculta Rapids area did not occur because of the cold water barrier. Manila clams require a temperature of 14 degrees Celsius for successful breeding (Mann 1979). It was felt that spread north of Vancouver Island would not occur for the same reason.

In 1972, Manila clams were found in Spider Anchorage and further investigations showed populations in the Bella Bella area. The farthest north population is at Rescue Bay in Mathieson Channel. In addition, populations were found in Queen Charlotte Sound as far south as Port Harvey. It is believed that these populations came originally from spawnings in the Quatsino Sound.

Two intentional transplants of Manila clams were made, one in 1962 to Masset Inlet and Naden Harbour and the other in 1969 in the Principe Channel area. Populations at both locations did not survive and apparently no breeding took place.

It is unlikely that Manila clams will spread much farther north of the Bella Bella area because of cold water temperatures. However, if a race developed that was able to breed at colder water temperatures then Manila clams might spread quickly to more northern areas.

CLAM CULTURE

I would like to begin my brief comments on clam culture with a statement by Dr. John Manzi (1985). "Most techniques for the commercialization of clam culture in the United States have been established for many years, they have only awaited appropriate application". The same statement is true for Canada and in particular for British Columbia. Perhaps as a results of this workshop we will know why this is the situation in British Columbia and whether clam culture has a future in our Province. Certainly clam culture is widely practiced in many parts of the world and probably about half the world's clam production is from culture or enhancement operations. I would like to say a few words here about potential species for culture and technical considerations for culture in British Columbia.

SPECIES

The first consideration in clam culture must be the species that we intend to culture. At the Pacific Biological Station we have experimentally cultured butter, littleneck and Manila clams. In Washington, experimental culture has been done with geoducks, razor and Manila clams.

It appears that culture of Manila clams has the greatest chance of being economically viable in British Columbia in the immediate future. It is one of the fastest growing species that occurs in the Province, reasonable rates of production can be achieved, there is a strong market for it at present (although markets may change), and seed is available. It is the one under consideration in the following remarks.

WASHINGTON SITUATION

Manila clam culture is now practiced in Washington although the situation there is different than in British Columbia. In Washington, intertidal areas may be owned and most landings in the commercial fishery for natural stocks are from these areas. The management theory has been that owners will do everything possible to maintain maximum levels of production. In a sense, they are practicing clam farming.

In British Columbia, intertidal areas can only be leased and further, a diligent use policy is in force so a grower must demonstrate that he/she is actually doing something to enhance production from the area.

There are no data comparing production from farmed and unfarmed areas along the east coast of North America. One estimate by industry claimed production in some areas had doubled as a result of culture.

Experiments must be undertaken to demonstrate the advantages of clam culture over simply harvesting wild populations.

CULTURE TECHNIQUES

One of the first things that must be done is to define what is meant by clam culture. Several practices are used in clam culture and all have lead to increased production for a given area.

Planting Hatchery Seed. In a vegetable garden, at least one seed must be planted for each plant that is harvested. Is this the definition of clam culture that will be applied? There are no data showing the benefit of planting Manila calm seed on the west coast of North America. Production in culture areas has increased but much of the increase could be due to good husbandry practices with natural settlement. Estimates of the amount of production directly attributable to planted seed range from 5-30%.

Improving the Bottom. This can be done by spreading gravel of a particular size to make the bottom firmer and a more suitable habitat for Manila clams. It also provides interstitial spaces where juvenile clams can escape predation.

Improving Natural Recruitment and Spat Survival. Manila clams are prolific breeders and there appears to have been excellent recruitment in recent years. If natural recruitment were enhanced and spat survival increased, would there be any need to plant seed?

Controlling Predators. Clam seed is preyed upon by many predators including a variety of crabs and fish. If predators were eliminated, would production from natural sets greatly increase?

Rotational Digging. Clam beaches are frequently redug many times during a year and this causes damage to sublegal size clams. If digging were done on a rotational basis, would production of an area increase?

These can all be considered as definitions of culture.

Experimental studies are needed to determine if large scale seeding is necessary to maintain production of areas at maximum yields or if it can be accomplished with improved husbandry methods with natural recruitment. If seeding is required then such questions as optimum size of seed and optimum planting densities to maintain maximum yields should be investigated.

Polyculture. Another field that should be thoroughly investigated is the feasibility of polyculture, growing two crops on the same piece of ground. Manila clams and Pacific oysters appear to be well suited for such culture. Both species can be grown at the same intertidal level and can be grown to harvest within three years. This would appear to be an excellent way to begin clam culture in British Columbia since at least one crop would be harvested and there is the possibility to double the profit from a lease. Further, it could be done on existing oyster leases so some problems associated with leasing would be alleviated.

New Methods of Culture. Existing culture methods are standard and we should certainly be willing to try any new culture methods. However, these should be well tested and demonstrated before they are turned over to industry. Culturing clams in raceways is feasible but hardly practical at present. Growing clams out of substrate is also not practical at present.

Utilization of the Beach. Manila clams occur naturally in the middle portion of intertidal beaches. However, Williams (1978) showed there was abundant spatfall in lower parts of the beach. Methods should be developed to culture Manila clams in the lower part of the beach since growth would probably be faster there and also mortalities due to environmental factors may be lower.

There are no panaceas in clam culture - it isn't a scheme to get rich overnight. There is a lot of hard work involved but this shouldn't prevent us from attempting clam culture in British Columbia. I have only introduced the problem of clam culture. Hopefully our deliberations here at this Workshop will shed some light on these complex problems and assist in establishing a clam culture industry here.

REFERENCES

Bernard, F.R. 1970. A distributional checklist of the marine molluscs of British Columbia. Sysesis 3. p. 75-94.

Bourne, N. 1979. Pacific oysters Crassostrea gigas, Thunberg, in British Columbia and the south Pacific Islands. In Exotic Species in Mariculture, R. Mann (ed). Mass. Inst. Tech. 79-9737. p. 1-53.

Bourne, N. 1982. Distribution, reproduction and growth of Manila clams, Tapes philippinarum (Adams and Reeves) in British Columbia. J. Shellfish. Res. Vol. 2 (1). p. 47-54.

Goodwin, C.L. 1973. Distribution and abundance of subtidal hard-shell clams in Puget Sound, Washington. Washington Dept. Fish. Tech. Rep. 14. 81 p.

Mann, R. 1979. The effect of temperature on growth, physiology and gametogenesis in the Manila clam, Tapes philippinarum (Adams and Reeves, 1850). J. Exp. Mar. Biol. Ecol. 38. p. 121-133.

Manzi, J.J. 1985. Clam aquaculture. In Crustacean and Mollusc Aquaculture in the United States. J.V. Huner and E.E. Brown, Ed. AVI Publ. Co., Westport, Conn. p. 275-310.

Neave, F. 1949. The spread of the Japanese little-neck clam in British Columbia waters. Fish. Res. Board Can. Pac. Prog. Rep. 61. p. 1-3.

Quayle, D.B. 1961. Deepwater clam and scallop survey in British Columbia. Fish. Res. Board Can. MS Rep. 717. 80 p.

Quayle, D.B. 1963. Deepwater clam and scallop survey in British Columbia. Fish. Res. Board Can. MS Rep. 746. 38 p.

Williams, J.G. 1978. The influence of adults on the settlement, growth and survival of spat in the commercially important clam, Tapes japonica Deshayes. Ph.D. thesis. Univ. of Washington, Seattle, Washington, U.S.A. 70p.

CLAM FISHERY STATUS IN BRITISH COLUMBIA

Mr. Rick Harbo, Department of Fisheries and Oceans

THE STATUS OF THE FISHERY OVER THE PAST FIVE YEARS

Species Harvested

The intertidal clam fishery harvests four species primarily, the Manila clam, the native littleneck, the butter clam and a minor fishery for the razor clam. Of the Manila clam and native littleneck, the Manila is currently the most important clam.

Landings and Value

The intertidal clam fishery has increased steadily over the past five years. The value and landings of intertidal clams has increased so that in 1987, intertidal clams were the most valuable shellfish species landed.

Figure 1: - Landed values of invertebrates (values paid to the fishermen) shows the intertidal clam values relative to other species. Within the clam species, the Manila clam is the dominant species.

Figure 2: - Landings of intertidal clams in 1987 were 4197 tonnes (9.25 million lb.) for a landed value of $6.5 million and a wholesale value of $10 million or more.

Over the past five years, the clam landings have increased steadily with Manila clams comprising the majority of the catch (Table 1). Up to the late 1970's, butter clams were the species in demand. The landings of the native littleneck clams have increased only a minor amount.

CLAM HARVESTERS AND PROCESSORS

The clam fishery has been a loosely regulated fishery in terms of licensing. There are only estimates of the number of clam harvesters since there is no requirement to have a sports fishing license and no unique commercial clam license. The holder of a Personal Commercial Fishing License (P.C.F.L.) is entitled to harvest clams. All fishermen are required to have P.C.F.L.'s, so it is difficult to determine how many are issued solely to harvest clams.

Figure 3:

i) Do-not have an estimate of native food fishermen.

ii) Estimate from the 20,000 P.C.F.L.s issued for 1988, that 3,000 to 4,000 commercial fishermen harvest clams. In individual areas such as Baynes Sound there are often 300-400 diggers at work.

iii) Estimate that there are 37,000 sports fishermen that

harvest shellfish (all species). We do not have a separate estimate of recreational clam harvesters.

iv) We have a record of 45 companies that bought intertidal clams in 1987.

v) Total number of clam culture leases issued as of November 1988 is 8.

CLAM BEACHES

We have recently carried out an inventory of clam beaches by statistical area in the South coast, attempting to assess their use by Indian food fishermen, commercial and recreational fishermen.

Figure 4: describes the number and area of beaches in the south coast:

i) In the inside waters between Vancouver Island and the mainland (Statistical Areas 12 to 19, 28 and 29) we have identified over 250 beaches: 165 commercial, 30 or more regularly used for food fishing, and 246 recreational beaches. Many beaches are utilized by all user groups.

The initial estimate of the area of the beaches is 4200 ha. It is important to note that there is easy access to many of these beaches by road or small vessels.

ii) The west coast of Vancouver Island generally has fewer beaches and they are more remote. Access is limited to many of the beaches to vessels only. Accordingly only about 20% of the Manila clam landings come from this district.

We have identified 98 commercial beaches, 17 regularly used for food fishing and 62 recreational beaches.

CLAM LANDINGS BY AREA

Figure 5: shows the landings of Manila, littleneck and mixed clams by area for the past five years.

When one compares the clam production areas to oyster growing areas, the competition for space and resources are apparent. The major clam fishing areas are also major oyster growing areas.

We currently have a working agreement between federal Fisheries and Oceans and the provincial Agriculture and Fisheries that the beaches identified as important fish habitat (eg. eelgrass beds) or supporting food fishing, commercial or recreational fishing will not be approved for the culture of oysters or clams. The impacts of this policy are being felt both by prospective oyster and clam growers.

We are also in the process of identifying several recreational reserves, areas with clam resources that will be closed to commercial harvesting

to protect and enhance recreational opportunities.

In conclusion, there is a valuable traditional and growing clam fishery on wild stocks. There will need to be careful planning to develop culture in harmony with the wild fisheries.

Question : Would you describe how you determined the areas set up for recreational reserves?

We initially set up a joint provincial and federal committee. We wrote to regional districts throughout the south coast and asked them to submit areas that they would like to see set aside for recreational harvesting only. Part of this program is that the regional districts will become involved in doing some of the biological sampling, signing the areas and helping out the management of those areas. Generally, the proposed areas have all been out in the Strait of Georgia in the high use areas of conflict between recreational and commercial growers. We carried out site assessments and tried to delineate reasonable areas.

Question : Many areas are harvested repeatedly until they have little stock. Will those areas be considered as potential clam leases?

We are still trying to formulate a policy as to what beaches we would approve for clam culture and at this point we are looking at it on a site specific basis. If there has been recreational food fishing or commercial fishing then we would deny leases. If there were some particular circumstances, we may review sites on an individual basis. That is the approach we are taking at this point.

Question : Could you please explain the difference between commercial and recreational beaches?

Most "commercial" beaches also have recreational or food fishing harvests. Some beaches, small in size, may not support a commercial harvest but may provide recreational opportunities for local residents.

Question : What will be the restrictions for commercial harvest on recreational reserves?

Generally when beaches are open, they are open to all harvesters, commercial, recreational or food fishermen. A recreational harvester can take only 75 clams but someone with a Personal Commercial Fishing License can harvest any volume. This has led to many conflicts on some accessible beaches. We have tried to identify and set aside some areas for recreational harvesting.

Question : Are all the proposed recreational areas on government land?

None of the areas that we have identified to this point are leased out in any fashion. Some adjoin provincial or district parks and some adjoin to oyster leases.

Question : I noted that your figures on landings were based on value of landings. Are these approximations of the actual poundage of

landings in the major producing areas on the inside here for the historical trends for say the last 10 years?

Figures are presented based on landings (tonnes) annually and by area. Landings have increased approximately four or five fold in most areas in the Strait of Georgia and on the west coast.

For example, Figure 5 shows the landings over the last five years. Tonnage in Area 17 over the last five years has been 2,500-3,000 tonnes. Landings in 1987 were 3 or 4 times what has been taken in previous years. There has not been a decrease in landings for any area. For every area of the coast, the landings have gone up in the last five years. Every little pocket beach can be exploited now because of the high value of the clams and the people that are harvesting them are working harder in all sorts of marginal areas.

Question : Do you think Manila clams are currently being over harvested?

We hope that we can sustain current yields. It's alarming the way that the landings have increased and we're getting close to the point now where we are fishing new recruits. Recruitment of Manila clams appears to be consistent, but if there is recruitment failure, there will be a drop in the landings. We may have a fishery failure at some point, and it is going to look like the resource has been mismanaged. The decline, however, may be a result of a poor year or years of recruitment over which we have no control.

Question : Do you expect clam landings to increase?

From preliminary landings in 1988, it doesn't appear that landings have significantly increased over the last year, so probably landings are close to peaking out. There are still many areas on the west coast of Vancouver Island and in area 12, on the north part of the Island, that aren't currently being harvested. It hasn't been economically attractive to harvest those areas. However, the landings may continue to increase because harvesters will exploit these new areas or it may just compensate for landings decreasing in other areas. That is something that is hard to predict.

Question : How are we protecting the wild stocks?

We are looking at a number of management steps to control effort and try to protect beaches from being repeatedly dug over. We are concerned that there are significant mortalities of pre-recruits from digging a beach many times during the season.

Question : Are there any limits to clam licenses?

That is an option under review. Until we have a clam license that identifies who the clam diggers are, limitation is a difficult option at this time.

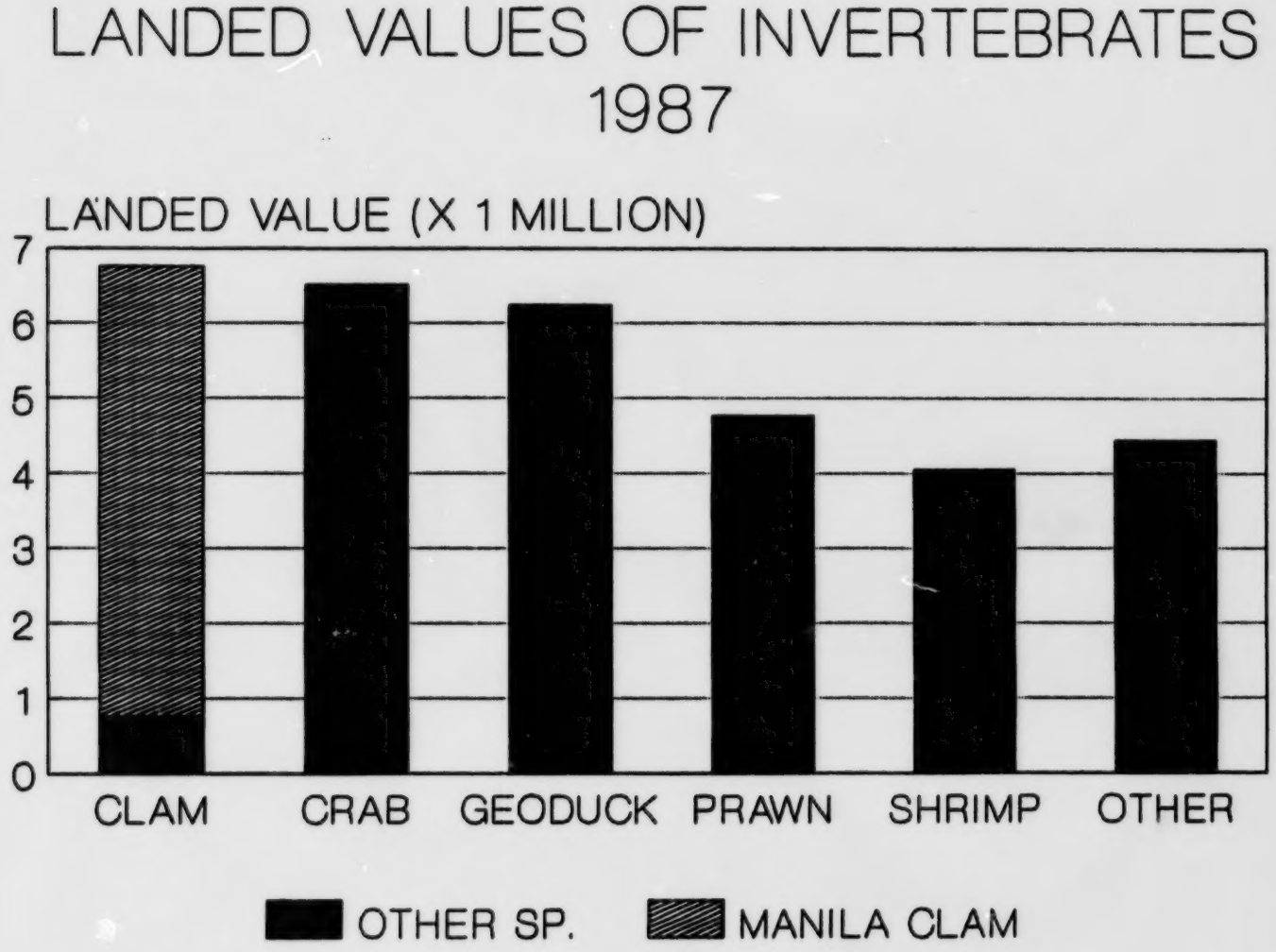


Figure 1: Landed values of invertebrates in 1987.

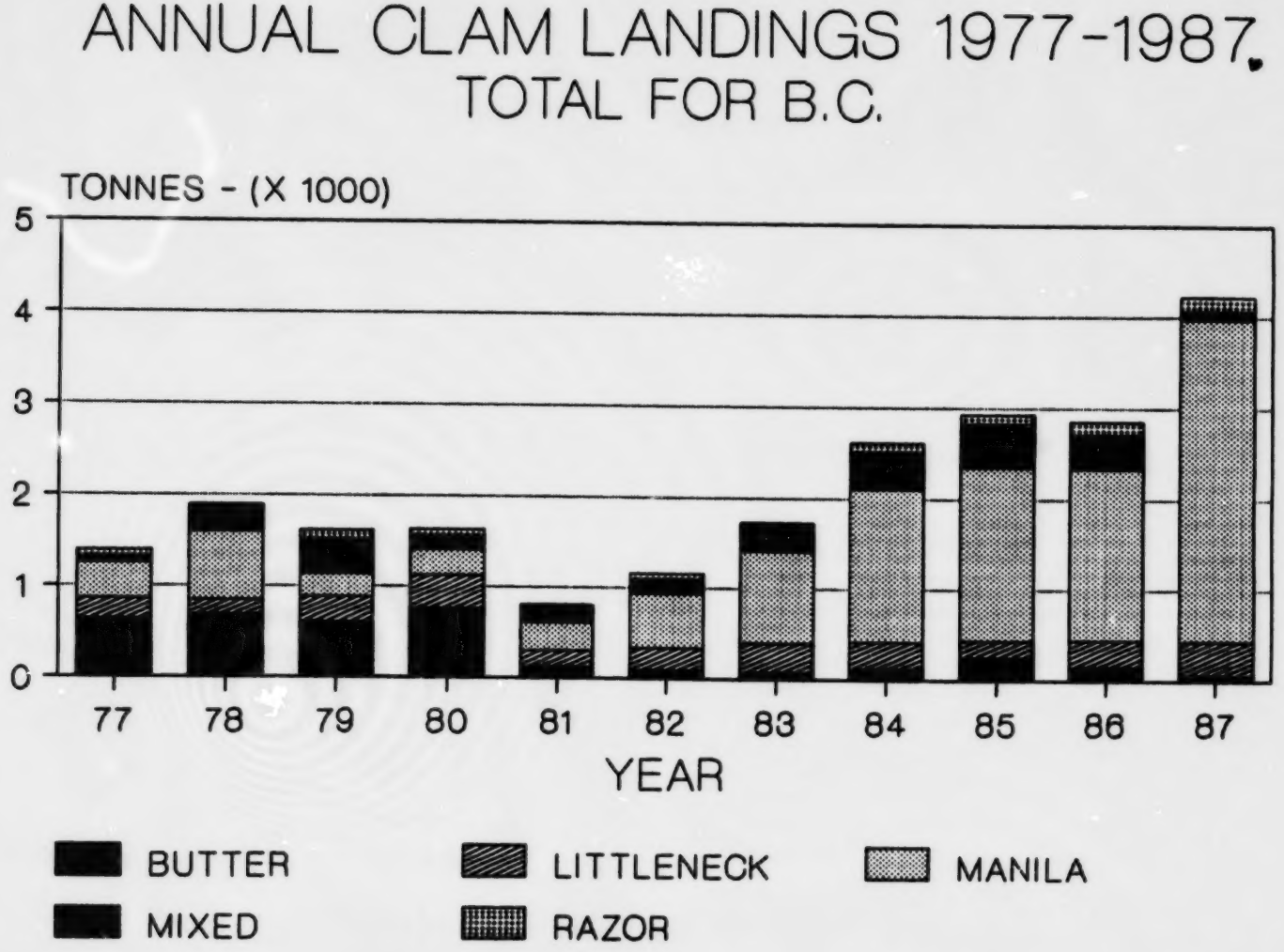


Figure 2: Total annual clam landings in B.C. from 1977-1987.

Table 1: Annual clam landings (tonnes), 1951 to 1987, for British Columbia, as reported on sales slips.

Year	Total Landings (t)	Landed Value (10-3)	Butter (t)	Little-neck (t)	Manila (t)	Mixed (t)	Razor (t)
1951	1977	149	1598	237	81	0	61
1952	3023	222	2493	224	184	65	57
1953	2081	127	1675	140	176	20	70
1954	1713	104	1315	66	204	5	123
1955	2517	159	2172	36	207	3	99
1956	1676	102	1455	14	99	*	108
1957	1743	102	1608	10	29	11	85
1958	1102	65	988	18	15	6	75
1959	1246	75	1095	22	25	13	91
1960	1973	133	1801	41	6	23	102
1961	1061	76	829	46	48	34	104
1962	1799	139	1520	92	69	43	75
1963	1427	103	1242	59	59	*	67
1964	715	59	570	69	26	1	49
1965	952	106	705	82	97	0	68
1966	1122	125	832	105	149	1	35
1967	1253	163	976	139	92	*	46
1968	681	98	399	91	164	15	12
1969	581	85	378	107	80	7	9
1970	1050	184	793	145	79	15	18
1971	1156	235	569	361	153	11	62
1972	1561	382	646	632	265	1	17
1973	715	196	297	207	136	0	75
1974	1111	383	531	328	183	0	69
1975	1174	333	747	236	158	6	27
1976	1603	340	656	173	199	70	505
1977	1391	545	650	209	394	60	78
1978	1890	834	686	159	753	245	47
1979	1612	916	613	273	251	374	101
1980	1632	1001	760	358	288	151	75
1981	806	737	120	178	317	161	30
1982	1159	1141	103	237	595	155	69
1983	1727	1687	77	325	1014	280	31
1984	2614	2758	131	295	1677	410	101
1985	2921	3144	252	191	1910	478	90
1986	2851	3805	159	285	1894	371	142
1987	4227	6522	65	373	3544	87	158

1. Years 1957-69 from Quayle and Bourne, (1972).
2. Years 1970-87 from sales slip records.

* less than 500 kg.

INTERTIDAL CLAMS – BC (1987/88)

? native food fishermen

3000 – 4000 commercial fishermen

? 37,000 sport fishermen

45 companies

4 to 5 clam culture leases (exp.)

Figure 3: Intertidal clam users in B.C. (1987/88).

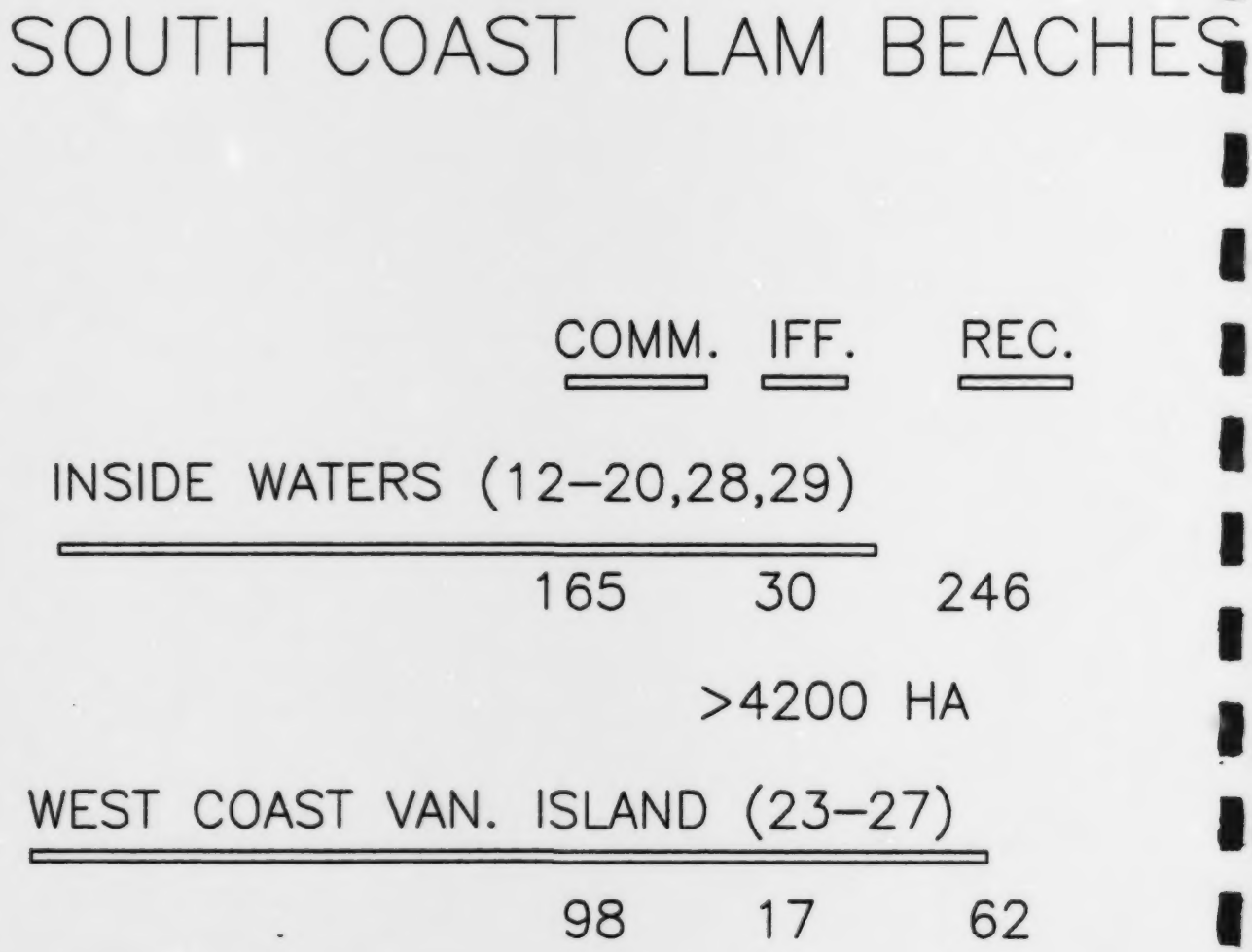


Figure 4: Numbers and categories of south coast clam beaches.

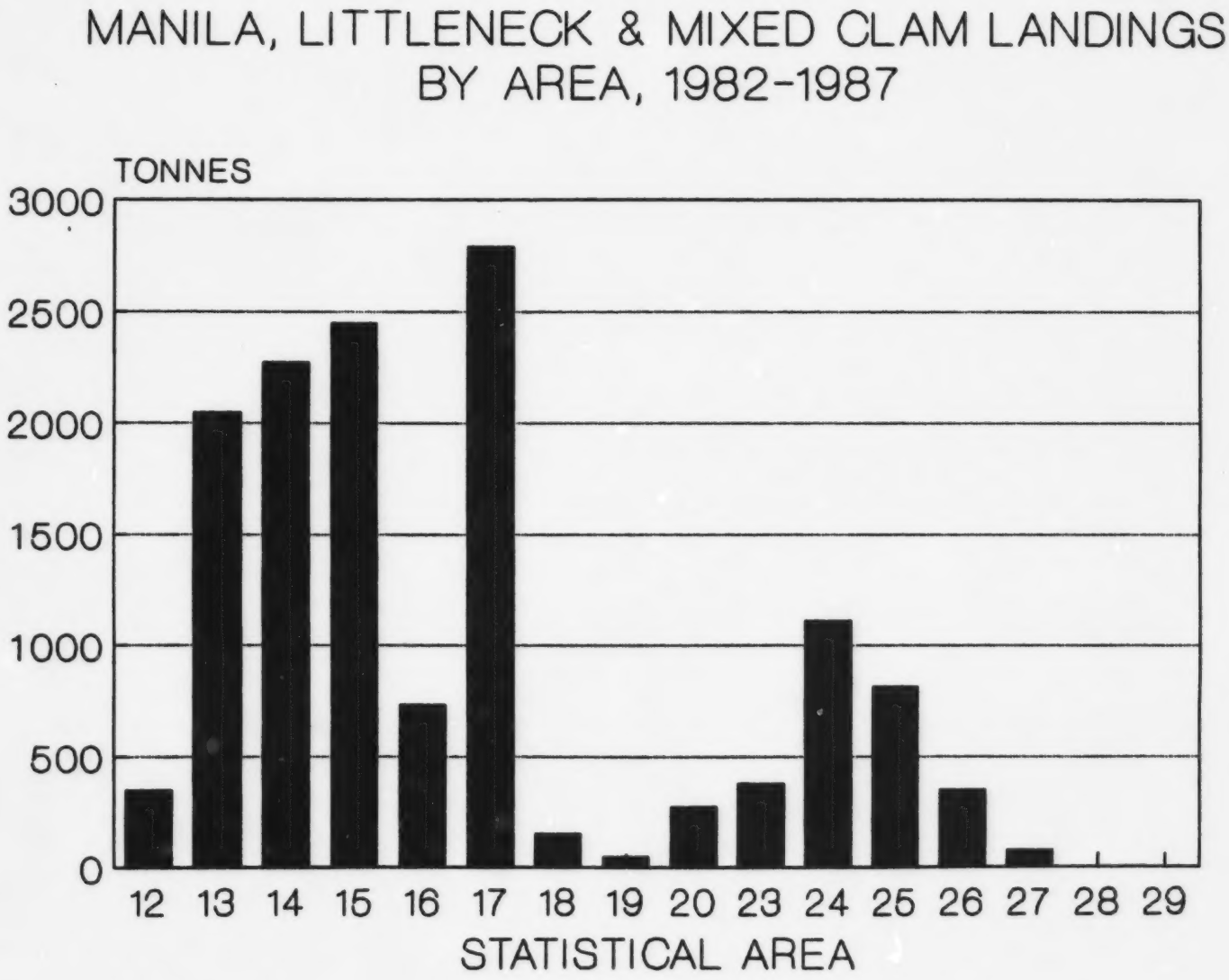


Figure 5: Manila, littleneck and mixed clam landings by area, 1982-1987.

BRITISH COLUMBIA FARMER'S EXPERIENCE

Mr. Norm Gibbons, Redonda Sea Farms Ltd.

I am wondering what we are going to learn in the course of the next two days. Possibly we're going to learn that landings of clams can be dramatically increased through enhancement and clam culture techniques. Possibly we'll learn that B.C. has the finest growing ground and water quality for production of Manila clams in the world. Possibly we'll learn that hatchery technology is commercialized to the extent that all the seed we would ever want could be readily available at reasonable prices and possibly we'll learn that grow out technology is moving along very quickly and the leaders in this area, who are our counterparts in Washington, are very willing to share this technology with us. And we'll possibly learn that the market for Manila clams is totally and absolutely insatiable and that the demand will far outstride the supply. This all sounds very positive but I think what we might also learn is that existing federal and provincial regulations are designed to frustrate the development of an enhanced and cultured clam industry in British Columbia and this is what I would like to concentrate on for a few minutes. I'll concentrate on this by giving a few examples of regulations and policies that are in place that are going to frustrate the next two days.

Example number one (and Mr. Rick Harbo stole my thunder on this one) - there is a provision for clam tenures in the province but it is only on grounds where clams don't grow. Manila clams were introduced here about 50 years ago and all by themselves they figured out the best places to survive and the best places to thrive and if it were up to us to figure that one out, it would probably take a lot longer than 50 years. The task that we have before us now is to go where the Manila clam is not located and to somehow create a clam industry in areas like that. You know when you compare it to other farming models you sort of wonder what the reasoning is behind that. We all know where you grow apples and where you grow grapes and we all know where you grow salmon and so on and so forth but you don't start out on the most marginal ground. You start out on the most optimal ground possible. I just wonder if our Washington counterparts have the same problem, if they're expected to enhance and to culture their clams on ground similar to the ground that we are going to have to culture clams on.

The second example has to do with the transplanting of natural seed stocks. Because of the size limit in our regulations, it is illegal to be in possession of an undersize clam. We can't move natural seed stock at all so there is no potential at all with existing regulations to enhance the fishery in any way, shape, or form. You only have to talk to the people who are out there all the time, the clam diggers, and they will tell you about the vast resources of undersize clams that are high intertidal on a lot of our beaches in British Columbia and the tremendous resource of natural seed that is sitting there. If it was moved a few feet lower down the tide line possibly the production in B.C. could be increased dramatically simply through that and none other. BUT regulations don't allow for this.

I guess another example would be polluted clams. There are considerable areas in B.C. where unfortunately there are large populations of legal size clams, but they are polluted and there is no provision in our regulations to be able to move those stocks into a certified clean area or into a depuration facility so that they can be cleaned and go to market. However, our counterparts in Washington are able to do that. They can relay their clam stocks from a polluted area to a clean area and leave them there for a week and then they can go to the market. In fact, we CAN do this in the oyster industry in British Columbia. If our oysters happen to be polluted on one of our oyster leases, we can get a permit and permission to move those stocks to another area, relay them for a two week period, and then they can go to the market place. BUT we can't do that with clams.

Recently the provincial government and the federal government developed some new regulations regarding the harvesting of clams on oyster leases. There are a whole variety of problems with that particular agreement but one that I find difficult to understand is that if the area that your lease happens to be in is closed for conservation purposes, you can't harvest clams on that lease. Just to give an example, let's say we have a lease in area 15 and area 15 is traditionally shut down from May through to October. Let's say on one of our leases in May we strip an area of oyster stock and underneath the oyster stock there is a lot of clams, so in June we would like to harvest that area and then maybe in July and August reseed the area with oysters. Technically we are not allowed to touch that clam stock.

Now I think that there are more examples than this but my point is that all the research, goodwill, new technology, and financial resources are going to be for naught unless a framework of government regulations and policies are conceived which will create an authority to plan and to build a clam industry. The policies and regulations right now are so negative that there is not going to be any investment and/or energy put into developing the industry. In listening to the talks so far, it sounds like all that the Department of Fisheries and Oceans plans is to manage the wild fishery, to find out how many diggers are out there, start licensing and maybe establish quotas. My view is that this is short sighted, that we should be thinking beyond this now. This would be a long term plan but there are numerous examples in British Columbia (say with our own oyster industry) and in other countries (like Japan) where fisheries have been enhanced and the fishermen have been involved in the enhancement process. I'm specifically thinking of the scallop industry in Japan where they figured out how to collect and nursery seed and they figured out how to broadcast the seed into some very large subtidal areas. Those areas were gridded off and tenured to fishermen co-ops and as a result they have an incredibly large, thriving scallop industry. You can call it culture, you can call it enhanced fishery but the point is that there is a lot more scallops coming out of Japan than there ever were before. I suspect that the same possibility exists for us in British Columbia. Mr. Rick Harbo is suggesting that our harvests have peaked and I think that he is right. Just about every square inch of clam ground has been scratched in the last year by clam diggers. If our approach is to strictly manage the wild resource and if all of our regulations and policies are designed strictly to manage what is out there right now, and if we cannot think positively enough to create an

atmosphere for enhancement and/or culture, I don't even think we'll be able to plateau the thing. I think we are just going to create a whole lot of social and political problems and it is going to be embarrassing for some people to answer a whole lot of uncomfortable questions. The positive side of it is that there could be many more shellfish grown out there and the people that should be able to do it are the people that are involved in the clam fishery right now. These people really know about the substrate, know what happens to the substrate when a southeast comes along and what kind of predators are there. They know how a beach can come back. The clam diggers know a tremendous amount about the local area, about the fishery and if you sit down with a clam digger, I mean the professional ones, and ask what they really want, they say they just want to develop and improve their own piece of ground. We have to design some regulations and policies to make that happen.

Question : I wanted to know if any the grower's have had any experience with growing clams off bottom?

Mr. Ron LeBlanc : We did some tests with the Manila clam, the small stuff off the beach. We put them in trays and found that the survival rate was okay depending how far out you went. What we found was that the clam was not growing normally, it was growing like an eyeball.

Mr. Norm Gibbons : We also tried this. We placed the clams in open trays but we noticed that there was a lot of fouling and a high mortality. This was done in the Gorge on Cortez Island where there is a low circulation rate. Maybe they would do better if there was more water flowing through the trays.

Dr. Neil Bourne : We tried floating tray culture with Manila clams several years ago. We put fine mesh liners in Nestier trays and then put Manila clam seed in the trays. The trays were floating about 1 meter below the surface of the water. The seed grew well with few mortalities until it was about 1 cm shell length. The ventral margins of the shells then started to become convoluted and the anterior and posterior edges flared out. Heavy mortalities were experienced at that time. The other problem was that the trays became very fouled with a variety of organisms and these greatly restricted water movement through the trays. Some of the clams themselves became covered with fouling organisms.

Other people have experienced similar results, good growth and survival until the juveniles were about 1 cm shell length and then growth stopped and heavy mortalities began. Results were similar even when efforts were made to keep the clams and trays as clean as possible. Results indicated that a substrate was necessary for continued growth and survival.

Similar results were also experienced in the State of Washington. They eventually tried to keep Manila clams in floating trays that had a layer of substrate in them but this method proved impractical.

Question : I have a question for Dr. Neil Bourne. We've been harvesting clams for four years now and we find that as long as we alternate our harvest beds, we get great landings. Why

can't this be done in the industry?

Dr. Neil Bourne : In managing the clam fishery by size limit the idea is that only legal size clams are harvested after they have had a chance to spawn and the sublegal size clams are left in the substrate. These sublegal size clams will continue to grow and eventually enter the fishery. Under optimum conditions in southern British Columbia it requires about three years from the time of spawning until Manila clams reach legal size (38 mm shell length). As long as the small clams are not damaged during digging they will quickly rebury in the substrate and continue to grow. In fact growth can be increased because they are no longer in competition with larger clams. As long as you get recruits every year on the beach then the fishery will continue at a reasonable level. However, you may not get regular recruitment and if you don't have regular recruitment then there will be a gap, or gaps, in the groups of clams (year classes) on the beach. When these gaps occur then there are few clams for harvest and production will naturally decrease. Fortunately Manila clams are prolific breeders and recruitment appears to occur every year. The other thing that can happen is that sublegal size clams can be lethally damaged during digging. When beaches are only dug once a year the incidental mortality to these small clams is minimal, but when the beaches are dug six or seven times and when the beaches are left like no-mans land in the First World War, then the damage to sublegal clams can be extensive. These small clams are lost to the population and production will decline when they should have entered the fishery. So when managing the clam fishery by size limit, it is important to have consistent good recruitment and to dig properly.

Question : I have another question for Dr. Neil Bourne. If we culture clams on our own leases why do we have to obey the size limit? Since they are our clams why can't we harvest them at any size we desire? I don't believe there is a size limit in the clam fishery in Washington.

Dr. Neil Bourne : We should be very careful when comparing our situation in Washington since the situation in Washington is different to ours. In Washington the intertidal area can be owned and almost all the commercial clam harvest, whether from digging natural populations or cultured clams, comes from this area. It is my understanding that although there is no size limit in Washington, the industry harvests clams at a larger size than we do. They rarely harvest Manila clams smaller than 40 mm shell length.

The theory in managing our clam resources by size limit is that it provides an opportunity for the clams to spawn at least once before they are harvested. If areas are set aside for clam farming you will still have areas where wild harvest can continue. However, you require a certain mass of broodstock to maintain natural populations of clams on beaches. If you harvest clams on cultured areas before they have had a chance to breed then you are reducing the natural breeding population and populations on beaches where wild harvest occurs could decline. Further it could also adversely affect populations on beaches that are cultured. If you are relying on natural settlement in a clam culture operation then you want as large a breeding population as possible to insure that you have good recruitment on your beach. If you harvest

clams from your culture area then you are simply reducing the chances of having good recruitment on your beach.

Question : You brought up several points on the rights to harvest clams or culture them. Ar there movements underway to change the laws and regulations, and if there are, what do you expect?

Mr. Norm Gibbons : Maybe these two days are part of the movement that is underway. I don't know. I think that there have been some very positive steps just recently. The fact that provincial and federal governments are able to work some sort of agreement, even though it is a compromise type of agreement to harvest clams on oyster leases and give oyster growers some protection over their oyster stock, is positive. It is one very small step but I guess that if the policy of the federal government is going to be strictly to manage the wild stock and nothing else, then we are wasting our time talking about enhancement or talking about culture.

Question : I was curious if you had looked ahead to see where your opposition might lie? I imagine that the people that manage the resource, there are those that are going to be sympathetic towards what you want and there will be others that will brood that they are not given a total mandate to protect their resource for the public. Those are among the people in power.

Mr. Norm Gibbons : That's right. There are going to be a lot of user groups so there will have to be a lot of compromises. There is a jurisdictional battle - I mean whose jurisdiction is clams? Federal or provincial government? Somebody has to be in charge of it. Somebody has to take the lead role and that one has to be sorted out.

Question : Why are these regulating agencies delaying new legislation?

Mr. Norm Gibbons : They are not really delaying but I don't understand why the federal government cherishes the Manila clam? It is Crown property. It is an exotic that was introduced over 50 years ago into British Columbia. It is only a recent introduction. The stand by the federal government is to protect this natural resource.

Question : Don't you think these laws are in place to prevent over digging which may wipe out the Manila clam?

Mr. Norm Gibbons : Nobody is suggesting that we wipe it out. What we are suggesting is that we manage it and enhance. I think that if we just try to manage it, and nothing else, we will go nowhere. In fact, what is happening now is that the management policies that are in place are threatening the industry. We have peaked now ! Until now, we have been taking clams out of the ground that are maybe 7 years old. They are only an inch and a half and they are legal but it took them 7 years to get to that size. On other beaches it takes 2 years and they are legal. We have been working around where populations are different age classes and now I think we are going to start seeing some big gaps because every beach doesn't produce a legal size clam in two years or

three years. We have scratched over all that old stock.

Mr. Jim Anderson : I am not going to provide an answer or state a policy position at this point of the workshop but it is important that we understand the issue. If we leave the fisheries for a moment and even leave federal/provincial government disputes, this question is now being asked in forest management in B.C. where it is clearly a matter of provincial purview. Forests for everyone, as common property resources that we all share and in some sense have equal access - OR should forests be alienated and turned over to become the responsibility of private companies who will manage it. Who will make profits or not make profits as they bare costs of harvesting and managing? Canada, particularly western Canada, has a tradition of common property resources that are in some sense managed by public agencies. Now we are reaching the point where Mr. Norm Gibbons is asking the question, can we manage clams as a public resource effectively? Or has the time come to admit that in order to effectively maximize the opportunity that the clam resource provides that it has to be turned over and managed by private tenure holders who will enhance wild populations and the natural habitat and have exclusive right to harvest. That is the bigger issue. Where do we go beyond the clam/oyster protocol that was signed last year? At least we are beginning to deal with the issue. Until then no one even wanted to deal with the question, in fact they wanted to avoid it. The clam/oyster protocol between the federal/provincial government has imperfections, but at least it is the beginning of asking that bigger question and maybe by the end of tomorrow there may be answers.

Editor's Note : Mr. Jim Anderson is presently the Acting Director of Aquaculture and Commercial Fisheries, Ministry of Fisheries and Agriculture which is the lead agency of the provincial government for the aquaculture industry in British Columbia.

BRITISH COLUMBIA FARMER'S EXPERIENCE

Mr. Ron LeBlanc, Garden Bay Seafoods

Many of the industry concerns have already been addressed; however, I would like to discuss in greater detail some of the problems facing the industry such as pollution. As you may know, everybody is so pressured to produce that they go into polluted areas and dig. Once Department of Fisheries and Oceans (D.F.O.) (Vancouver) informs us that the clams are polluted, it is too late and as all the processors sitting here know, we have a major problem. The solutions we hammered out this summer certainly helped us but we are a small company so we can more easily control the problem. The pollution is caused by sewage and boaters. And even though the beaches are closed due to pollution everybody is out there digging. It is a major problem. What we do about it, I don't know. I guess we are here this week to see if we can find answers.

Another problem is over harvesting. Some of our beaches, like Savary Island, are getting hammered so hard the population probably dropped 50% in the last week. The local clam digging crews are moving out of the area because they can't make a living. The clam digger goes out at night and he makes 50 bucks, he doesn't even cover his costs. All of these things are happening now because these areas are being over harvested. I am looking at this thing and I am saying to myself, what am I getting into the clam business for because it is just creating problems. I believe there is certainly something that can be done about these problems.

One solution is to allow <u>professional</u> clam diggers to get their little piece of ground and work it. I am not talking about the guy who goes digging 2-3 days every 2-3 weeks but the guys that make their living digging clams, they are professionals. They go out and they dig for a whole tide and they bring you a good product to take to the market. Good areas are getting so remote that these guys can't get out there. It is a major problem. The solution, as Mr. Norm Gibbons suggested, is that maybe they should have a little chunk of beach they could look after and harvest. It went like that with the oyster situation from what I can see. Dr. Neil Bourne was talking about polyculture, well that would probably be the answer to a lot of these problems.

There is another problem facing the oyster farmer. We now have markers we can put on our beaches to identify boundaries but they only create an imaginary line. People cross the lines, pile up the oysters and walk over your seed to dig up the clams. Even if you have a program stating the days you are going to be harvesting and so on, for an oyster farmer to go out there and supervise his beach is impossible. Ninety percent of the leases are remote and you just can't be there all the time. In some cases, I know it happened to us, clam diggers come over to your oyster lease, they move your oysters or walk over them and before they leave they take a few bags with them. It doesn't help the profitability of oyster farming. Supervised digging, I guess, has eliminated a lot of problems with the polluted and illegal clam harvesting but I don't think it is going to be the answer to everything. We can probably supervise a certain volume of clam digging but when you are buying big volumes, I

just can't see how that is going to work. A depuration system would probably be the answer to that.

Depuration is carried out in different parts of the world but we're not doing it here. We could probably go into polluted areas with special permits, dig the clams, place them in a depuration system and market them as a certified clean product. It would certainly take a lot of pressure off the industry.

Another issue I would like to address is the availability of clams. The government figures production is peaking. I think we are past that point. You go to your market and there is a shortage of clams. You try to get a hold of product and can't get it. You short your orders and lose customers. The problem is there, all we have to do is try to work out some sort of solution that allows us to remain productive, otherwise the industry will not continue. It's just not profitable at all. I like to be in business to make money and create jobs too but it is getting to be a major problem all over.

Planting clam seed on your own leases could be one way to solve the problem. The present clam industry is a dying business and possibly clam farming may be a future business. We have to look at this industry in a totally different way or otherwise we better pack up.

These problems give us a lot of headaches. If the government can do something about them, change a few rules, legislate new rules, or whatever, to help the farmer, I think the industry will start going and growing but the way it is now I think we are just spinning our wheels and it is not going to get any better. It gets worse and worse. It's time to act on this and look for examples to what our American friends are doing.

I was talking to a gentleman from the States this morning and he said they were culturing clams on their own beaches for over one hundred years. There is no reason why we can't do this here, no reason whatsoever. Trying to protect the wild clam is a good idea and people like to have everything just the way it was, but if we are going to farm, this is what we have to do. I hope that we can work out something in the next day or so that we can walk out of here and start having something solid to work on otherwise I think we are going to have a hell of a time with the industry.

OPENINGS AND CLOSURES OF BEACHES - CLAM MANAGEMENT

Mr. Rick Harbo, Department of Fisheries and Oceans

Due to the lower levels of effort and landings, the sports fishery is managed by daily bag limits rather than minimum size limits.

The commercial fishery is managed primarily by rigorous enforcement of the size limit. A clam buyer recently received the maximum fine of $5,000 and forfeiture of product for undersize clams. The minimum size limit allows Manila clams to spawn at least once before being taken in the fishery. Other management restrictions include gear restrictions (hand digging only) and seasonal or area closures (Figure 6).

A clam license for commercial harvesters is expected to be in effect in 1989. As well, a shellfish license may be required for sports fishermen. The licenses will greatly improve the transfer of information to harvesters and allow for improved effort and catch statistics.

Supply and Demand

Figure 7 illustrates the 1987 clam landings by month for the east and west coasts of Vancouver Island. Industry has advised us that they want to provide a year round supply of steamer clams from the wild fishery. By staggering some openings, we have managed to maintain supply throughout the year as illustrated in Figure 7. This may be affected in 1989 by paralytic shellfish poisoning (P.S.P.) or conservation concerns.

Seasonal and Area Closures (Figure 8)

Beaches or areas have been closed when they are considered to be fully exploited. When there are problems with sublegal clams being landed, the area is likely fully exploited. A closure is usually effected by a Fisheries Public Notice posted by the local Fishery Officer.

There has also been increasing concern about mortalities of sublegal clams from repeated digging of a beach in one season. However, as discussed before, due to the large number of beaches it is not practical to manage by individual beaches. In the Strait of Georgia alone there are 250 to 350 beaches supporting clam fisheries.

Some seasonal closures have resulted from conflicts between users. Savary Island is opened at times, fall and winter night time tides, when there are fewer recreational harvesters. Baynes Sound has been limited to periods of daylight tides in an attempt to improve compliance and enforcement of harvest of clams in the vicinity of oyster leases.

There have been an increasing number of area closures and in one area, Savary Island, the fishery has been limited to three days per week. Other closures for P.S.P. and contamination will be discussed by other speakers.

In 1988, there were often 100 to 300 commercial diggers on a beach. Some areas will be closed to commercial harvesting in 1989 to maintain and enhance recreational opportunities.

There are reduced fishing in many areas but we have attempted to stagger openings to spread out effort and landings over several areas and to maintain a year-round supply.

Clam management and the control of effort is a complex problem. It is likely that landings from the wild fishery will greatly exceed cultured clams for many years. However, cultured clams may certainly be a benefit to the clam industry, to maintain a constant supply and to expand into new markets.

To illustrate the complexity of the situation, I have included Table 2, presenting data on the ranges of mean densities of intertidal clams from various commercial beaches in B.C.

CLAM MANAGEMENT

- SIZE LIMITS (38 mm – manila)
- BAG LIMITS (sports)
- SEASONAL RESTRICTIONS
  - biological
  - economic
  - management
- GEAR RESTRICTIONS
- AREA or BEACH CLOSURES

Figure 6: Clam management in British Columbia.

Figure 7: Manila, littleneck and mixed clam landings in areas 11-29, by month, in 1987.

SEASONAL/AREA CLOSURES

- BIOLOGICAL – reapeated digging
- PSP RISK
- ECONOMIC – maintain year round supply
- MANAGEMENT
  - undersize
  - repeated digging
  - user conflicts

Figure 8: Seasonal and/or area closures.

Table 2: Ranges of mean densities of intertidal clams from various commercial beaches in British Columbia.

Species	Location	Statistical Area	Total clams $\bar{x}$ No.·m^{-2}	Legal Size $\bar{x}$ No.·m^{-2}
1. Manila clams (Tapes philippinarum)	[1]False Narrows	17	2 - 50	0.7 - 17
	[1]Nanoose Bay	17	55 - 175	4.7 - 9.4
	[1]Savory Island	15	16 - 591	6.6 - 89
	[2]Hillary Island	23	190 - 360	42 - 126
	[2,3]Atleo Beach	24	49 - 114	8 - 47
	[4]Mary Basin	25	6 - 268	5.1 - 174
2. Littleneck clams (Protothaca staminea)	[1]False Narrows	17	5 - 32	3.4 - 22
	[1]Nanoose Bay	17	2 - 18	1.2 - 9.4
	[5]Savary Island	15	3 - 37	1.6 - 9.4
	[2]Hillary Island	23	1 - 27	0.4 - 5.3
	[2,3]Atleo Beach	24	241 - 439	33 - 63
	[4]Mary Basin	25	46 - 216	8.8 - 108
3. Butter clams (Saxidomus giganteus)	[6]Seal Island	14	-	15 - 400
	[2,3]Atleo Beach	24	40 - 89	28 - 40
	[4]Mary Basin	25	0.3 - 25	0.7 - 7
4. Razor clams (Siliqua patula)	[7]North Beach Masset	1	2.9 - 7	
	[7]South Beach Masset	1	2.2 - 4	
5. Horse clams (Tresus capax, T. nuttallii)	[6]Seal Island	14	2 - 680	(no size limit)

Note : 1 to 6 cited in references.

References for Densities of Intertidal Clams

Harbo, R.M., N. Bourne, K. Hobbs and B.E. Adkins. In prep. Intertidal clam surveys in the Strait of Georgia.

Adkins, B.E., R.M. Harbo and N. Bourne. In prep. Intertidal clam resources on the West Coast of Vancouver Island, 1981 to 1987. Can. MS Rep. Fish Squat. Sci.

Bourne, N. and S. Farlinger. 1982. Clam survey Clayoquot Sound, British Columbia, 1980. Can. MS Rep. Fish. Aquat. Sci. 1634: 93 p.

Adkins, B.E., R.M. Harbo and N. Bourne. 1982. An evaluation and management considerations of the use of a hydraulic escalator clam harvester on intertidal clam populations in British Columbia. Can. MS Rep. Fish. Aquat. Sci. 1716: 32 p.

Bourne, N. and B.E. Adkins. 1985. Savary Island Clam Study. p 69-95. In G.S. Jamieson [ed.] 1983 and 1984 Invertebrate Management Advice, Pacific Region. Can. MS Rep. Fish. Aquat. Sci. 1848: 107 p.

Bourne, N. 1969. Population studies on the razor clam at Masset, British Columbia. Fish. Res. Board Can. Tech. Rpt. 118: 24 p.

OPENINGS AND CLOSURES OF BEACHES - SHELLFISH TOXICITY

Mr. Rudy Chaing, Department of Fisheries and Oceans

Shellfish toxicity has been a major problem and is an important criterion of the shellfish program because people get sick from it and some have died from eating toxic bivalves.

What causes toxic shellfish? Well, according to scientists, single celled phytoplankton or algae can start rapidly multiplying into huge numbers and some species of the algae contain a toxin which inhibits nerve transmission in human or mammalian systems. It is just like someone cutting the telephone cord. As a result of this, people get symptoms of paralysis and in severe cases they fail to breathe and die from asphyxiation.

The name of the species is Gonyaulax but Dr. Taylor at UBC has proposed the name Protogonyaulax in recent years for the same species. Now what causes the Protogonyaulax or Gonyaulax to be so toxic? They produce a chemical called saxitoxin and various derivatives all of which act to inhibit the transmission of nerve impulses. Some components are more toxic than the others but collectively they all contribute to illness. The latest recorded case was a couple of weeks ago in Prince Rupert, where two groups of clam diggers ate butter clams and ended up in the hospital.

Is there any antidote to the toxin? Unfortunately no, well none yet at least. The best thing to do is induce vomiting and take the patient to the hospital. With artificial respiration, it is expected that the patient will survive. From talking to some people who had inadvertently consumed toxic mussels, the description is that the patient is fully conscious but they cannot respond, they cannot talk, they cannot do anything. It was most frustrating because they could hear the doctor talking to the nurse saying "Oh yeah this guy is comatose" (i.e. unconscious) whereas they understood every single word of it, they just could not do anything.

People have often asked whether red tide blooms can be detected by visual means where the water changes color and turns red. Scientists have done lots of work on that and the answer, unfortunately, is no. Red tide blooms are usually not reddish in color but rather greenish-brownish. Usually they are mixtures of different species of which the toxic dinoflagellate is only one. By the time we notice any changes in the water color, it is too late. The bivalves would have concentrated the toxin to very high levels before our human eyes could perceive the difference in the water color or algae concentration. It is present year round all over the world at an average concentration of one cell in every twenty drops of seawater and at this level it is not considered to be toxic. When it gets to five cells per drop of water you will have approximately 100,000 cells in one litre of water. That is the stage that it gets toxic but we will not be able to perceive any water color changes until there are 50 cells per drop of water. This type of analysis gives us the basic appreciation that one cannot tell whether the shellfish is acceptable or not by color changes in the water as it

is too late by the time we notice any changes.

Protogonyaulax are called dinoflagellates because they have two flagella which will allow them to move. In fact some studies show that dinoflagellate organisms will go down to the deeper waters at night and in the morning they start migrating up towards the surface. In addition there is always the tidal movement which, depending on the wind and on the particular topography of the bay, could spread paralytic shellfish poisoning (P.S.P.) blooms in any direction. Some times P.S.P. blooms are sporadic in nature while at other times they could be massive. The challenge of any P.S.P. monitoring program is to find out when and where it occurs. Quite often people will say we never had P.S.P. problems in my part of the water. For example, the south end of Puget Sound had no recorded P.S.P. outbreaks until a couple of months ago when some people got sick from commercial oysters. Some of those oysters were exported to Alaska and other parts of the States.

How do we analyze it? The traditional and the acceptable method is mouse bioassay. Extracts of shellfish tissues are injected into the mice.

In recent years, a good analytical method has been developed using high performance liquid chromatography. The extracts are injected into a chromatography column where it gives a separation of different chemical compounds. Analytically it is important for people who are doing research. In terms of coming up with a quick method where people can do the toxicity determination on site (i.e. on the beach), there is no quick method yet.

To monitor for P.S.P. blooms, a sample of shellfish is taken from a site on a weekly basis. During a bloom, what appears to be okay today, may be toxic by tomorrow. The dynamics of the bloom depends on how quickly the cells are multiplying and how quickly the toxins are taken up. The challenge is to have the results before the toxicity level of the oyster or clam changes. The duration of a closure will vary, depending on whether there are any further outbreaks and how quickly the shellfish can get rid of the toxins.

There is no good way yet scientifically to predict the conditions that will trigger a bloom. We do know that the salinity, nutrient levels, the amount of sunlight, up lifting of the bottom sediment where the cysts are formed and the temperature of the water will contribute to bloom conditions. Scientists are still trying to determine what the critical conditions are that will trigger a P.S.P. bloom.

Here are some of the case histories that were reported. In 1793 one of Captain Cook's crew died. In 1982 an outbreak in Works Channel, had 30,000 micrograms of toxin in raw mussels while the left over cooked mussels had 14,000 micrograms. Do people die at 1,000, 2,000 or 5,000 micrograms? Again, there is no answer because each individual appears to have a different absorption rate to the toxin. The lethal dose also depends on how much has been eaten. So the person who has eaten 5 dozen mussels will obviously be at a greater risk than the person who only ate one. However, body absorption, body size and whether the individual has been running, jogging or consuming alcohol will also have an impact on

the uptake. If alcohol had been consumed then the faster blood circulation will increase the uptake rate, resulting in a more violent impact.

OPENINGS AND CLOSURES OF BEACHES - SANITARY SHELLFISH GROWING

Mr. Bruce Kay, Environment Canada

Shellfish are an unusual seafood product in that they can concentrate toxins such as paralytic shellfish poisoning (P.S.P.) and other pollutants to levels that may be dangerous to public health. Because of this, the regulations over their harvesting, processing and sale is perhaps much more stringent than any other seafood product. One of the reasons this is necessary is that many shellfish are eaten raw or partially cooked and the entire animal is eaten. Today I will briefly review Environment Canada's programs for the classification of shellfish growing areas. When I say classification, I refer to the water quality monitoring programs which are done to ensure that growing areas meet certain federal standards for bacteriological water quality.

There is a good history dating back to the late 19th and early 20th century of people becoming ill from eating contaminated shellfish. On the east coast of the United States typhoid outbreaks were traced to consumption of contaminated oysters. At that time the United States developed public health protection programs to safeguard the shellfish consumer. Canada has equivalent programs which begin at measuring the levels of contaminants in the growing water and identifying pollution sources. The next step is measuring the shellstock quality and sanitary conditions in the packing/processing plants. I am now going to review some of the pollution sources which can adversely affect shellfish growing areas. As people who are interested in clam culture, you should be thinking about these kinds of pollutants and where you might site clam culture activities to minimize the risks associated with contamination and potential closure of your beaches to direct harvesting.

Of course, sewage treatment plant effluents are an obvious source of fecal pollution. One source that is perhaps not so obvious, but which is a significant source of water quality closures in British Columbia, is agricultural and hinterland runoff. Boats also are a significant problem in some areas particularly in the summer. There are a number of seasonal closures in British Columbia associated with discharges from anchored boats. So in terms of clam culture areas, you would want to be careful that they are not associated with heavy boating activity.

Pump or lift stations from sewage treatment plants, irrigation systems, etc. can malfunction in the event of a power or mechanical failure and raw sewage or contaminated runoff can often be discharged directly to the beach areas. In many cases these occurrences are not accurately recorded. As a consequence these areas are closed on a permanent basis because of the lack of control systems to warn of malfunctions and overflows.

In addition to fecal pollution from farm and wild animal populations, marine mammals such as sea lions and seals, can cause fairly dramatic increases in fecal coliform levels of certain waters. A recent herring spawn south of Dodd Narrows attracted a large number (several hundred) sea lions and fecal coliform monitoring at that time showed the levels

to increase substantially, well beyond acceptable levels for direct shellfish harvest.

Industrial contamination is also a source of pollution to shellfish growing areas.

Table 3 shows trends in the areas under closure in British Columbia related to the variety of the sources just described. In 1972, the total area under closure was 51,655 hectares and in 1986 it was 54,785. This is not necessarily productive shellfish harvesting ground. This includes a number of areas such as Vancouver Harbour and the shoreline around Victoria so it is not necessarily indicative of productive shellfish areas being closed. I think what it does indicate is that the closures have not increased in large number relative to how much area was closed back in the early 70's. It is interesting to note that boat closures have increased from 452 to 1,436 hectares. Agricultural and rural runoff closures are also on the increase. These pollution sources are more apt to be located in areas where shellfish harvesting is occurring. In areas around the more populated Vancouver-Victoria areas, population pressures are such that shellfish harvesting is probably in conflict with other uses of the marine environment.

Table 4 shows some of the components of shellfish sanitary surveys. These include the: various sources of contamination; the hydrography of areas (eg. how the freshwater discharges impact on the areas, where the flows go); sampling periods (when we anticipate pollution to be at its worse); and tidal conditions. The bacteriological studies have to take into account: sample station location in relation to the pollution sources and the shellfish resources; whether to sample on a daily basis or during specific seasons; how many samples to collect; how to interpret the results; and the other kinds of analytical tools we need such as sediment collection, bacteriological quality of the shellfish tissues and the monitoring of the pollution inputs.

In Canada and the United States shellfish can only be harvested from waters of approved quality. The water quality standard states that the fecal coliform median or geometric mean of the water overlying the shellfish areas must not exceed 14 fecal coliforms in 100 milliliters of water and not more than 10% the samples that are collected can exceed 43 fecal coliforms per 100 milliliters (Table 5). To put that standard in perspective, the swimming water standard which is in effect in British Columbia and most other areas in North America allows swimming beaches to remain open up to fecal coliform levels of 200 per 100 milliliters so we are dealing with a water quality standard which significantly more stringent than the swimming water standard. The other important thing to note here is that even if water quality does meet that 14 fecal coliform standard, areas can be closed on the basis of our shoreline sanitary and reconnaissance work if pollution sources are identified which may pollute the water on a periodic basis (eg. sewage lift station overflow).

During a survey, water samples are generally collected six to twelve inches below the surface and taken to our mobile lab. This lab is designed to conduct the fecal coliform analysis at various locations around the province. The reason for a mobile lab is the very short time

allowed between collection and analysis to ensure valid results. Samples are analyzed generally within 5-6 hours of collection for fecal coliform organisms. Fecal coliforms are indicators of sewage contamination present in the fecal matter of all warm blooded animals including man.

Following the surveys, Environment Canada will analyze the data including appropriate statistical analysis, document the shoreline sources and then present the report to the Pacific Standing Committee on Shellfish. Closures are recommended to this committee, which is comprised of government representatives from Environment Canada, the Department of Fisheries and Oceans (D.F.O.), Ministry of Environment (B.C.) and Ministry of Agriculture and Fisheries (B.C.). The closures are enacted by D.F.O. who have responsibility for patrol, enforcement and posting.

Figure 9 shows the areas that have been surveyed by Environment Canada for sanitary quality. Areas that are still remaining are the northern parts of Desolation Sound and the Johnstone Straits area. These will be surveyed during our program plan for next year.

Table 3: Trends in British Columbia shellfish area closures.

	Year of Closure (Area in Hectares)							
Source	1972	1976	1977	1978	1979	1981	1984	1986
Multiple Source	45 407	46 233	46 213	45 654	43 540	44 018	44 457	44 151
Municipal Discharge	5 211	5 981	6 439	6 466	6 466	6 681	7 090	7 660
Urban Runoff/ Septic Seepage	439	639	969	1 097	840	789	1 184	903
Agriculture/Rural Runoff	146	272	369	503	503	630	609	635
Boat Discharges	452	301	315	301	344	344	1 387	1 436
Total (Hectares)	51 655	53 426	54 305	54 021	51 693	52 462	54 727	54 785

Table 4: Major components of a comprehensive sanitation survey.

SANITARY RECONNAISANCE	HYDROGRAPHY	BACTERIOLOGICAL STUDIES
A. Municipal Sources 1. sewage treatment plants 2. overflows and bypasses B. Industrial Sources C. Shoreline Sources 1. domestic, e.g., septic tanks 2. urban runoff 3. agricultural 4. wildlife D. Other, e.g., vessel discharges	A. Freshwater Flows 1. Past records a. stream flows b. rainfall effects 2. Time of survey a. stream flows b. rainfall effects B. Tides C. Current Patterns (droque studies) D. Temperature-Salinity E. Flushing (dye studies) F. Meteorological G. Bathymetry	A. Station Locations B. Timing 1. Seasonal 2. Consecutive days 3. Daily C. Number of Samples D. Interpretation E. Other, e.g., sediment, shellfish analysis, pollution inputs

Table 5: Criteria for classifying shellfish growing areas (sewage contamination).

CLASSIFICATION	CRITERIA
Approved	1. Fecal coliform "MPN" is less than or equal to 14/100 ml* and not more than 10% of the samples exceed 43/100 ml during the worst pollution conditions. 2. There are no potential pollution sources in the growing area which would contaminate shellfish under certain specific conditions e.g. sewage lift station overflows.
Closed	1. Fecal coliform median/geometric mean exceeds 14/100 ml and/or more than 10% of the samples exceed 43/100 ml during the worst pollution conditions. 2. There are pollution sources which could unpredictably contaminate the shellfish.

"MPN" - Most Probable Number
* - median or geometric mean

Figure 9: Areas surveyed (bold lines) by Environment Canada in the Molluscan Shellfish Program.

OPENINGS AND CLOSURES OF BEACHES - INDUSTRY RESPONSE

Mr. Norm Gibbons, British Columbia Intertidal Clam Processors Association

Recently one of the real positive things that has happened in the industry is that the processors have begun to organize themselves. The industry has not really been organized at all but as their first step, they formed what is called the B.C. Intertidal Clam Processors Association (B.C.I.C.P.A.). They had a meeting last night but to show you that we are not that well organized, I turned up at the right time but at the wrong place so I didn't make the meeting. Anyway, there was a meeting and I have an idea about some of the issues that the clam processors want to present today.

The clam processors have begun to organize because of the problem that has been developing over the last year of polluted product getting into the market. We were able to sit down with the Department of Fisheries and Oceans (D.F.O.) and work out a new quality control program for the harvest of clams and actually this is the document we produced. This is draft eight and we all worked pretty hard on it. I think we have developed some different ways of monitoring the product that is brought into the processing plants and getting into the market place. The voluntary program is just beginning and I think it will probably take at least six months to see if the program actually works. I think it is a very positive start and the clam processors would like to continue this type of dialog and cooperation between ourselves, D.F.O. and other agencies. So in relation to the subject of openings and closures, there are just a few basic points that we wanted to present at the meeting today.

The first point is that we would really like to be able to sit down and partake or consult in the development of regulations and policies regarding openings and closures. I think that we certainly have a different point of view but there are probably things that we see that the agencies don't and I think we have a role to play. There are other groups that aren't organized at all, such as the harvesters, that possibly should be involved in all of these discussions.

The second point that we wanted to make is that we are in complete support of the "undersize regulation"; we feel the inch and a half regulation is a good one and we encourage D.F.O. to enforce that regulation as consistently as they possibly can. To give you a private example of consistency, a number of weeks ago one of our trucks was stopped crossing the border and our load of clams were seized because the officers involved thought there were too many undersized clams in the load. The truck was sent back to Vancouver, the clams were seized. A wholesale company made a bid on the clams. The following day, under the supervision of Fisheries, the clams were inspected and they were able to come up with only five pounds of undersize clams out of 3,000 pounds. Fisheries then admitted that they had made a mistake and we received the bid price for the clams. We had some dissatisfied customers but at least we felt good that we had a much smaller volume of undersize clams in the load than was originally thought by Fisheries. The point that I want to make here is that on exactly the same night

that our load was seized at the border, there were Fisheries Officers in Lund that were enforcing size limits on clams being brought to the ramp by diggers. They were getting the diggers to take 50 clams out of their bags and if there were six undersize or less, they were letting them go through. At the border, we had less than 1% undersize clams and our load was seized yet in Lund, B.C., Fisheries Officers were letting 12% undersize go through.

Consistency is very important and we're totally in support of the regulation. I think that this regulation is probably the most important one and that it will help sustain the wild fishery better than any other regulation.

The other problem that we wanted to address about conservation closures is that we don't have all the answers. We wouldn't want to rewrite the book but it is our impression that the conservation closures do not always result in proper management of the fishery. One result of our current openings and closures policy is that we have now evolved a transient fishery. Five years ago it was local people digging clams in local areas. Now we have evolved to a situation where it is an almost 100% transient industry. The clams aren't transient like fish. Clams stay in the same place but we have this big travelling clam harvesting show going on in B.C. and it contributes to many other problems. It contributes to social problems, public pressure and so on. It contributes to a gold rush type of mentality that results in huge numbers of diggers converging on one small area. Instead of areas being open for longer and longer periods of time, we are developing a compressed industry. I suppose at some time in the future we will be looking at 24 hour openings. This year, on July 1st for example, area 14 was opened resulting in something like 100,000 pounds of clams a day coming out for about the first three days. There is no way the market can absorb that volume of clams in a three day period. The market can't absorb it, the plants can't absorb it. Instead of that volume of clams being harvested over a much longer period of time, it was all taken out at once. This also results in a lot of bags of clams getting left on the beach. Processors will not touch them so everyday processors are confronted by diggers trying to sell old clams and pass them off as recently dug clams. I don't know how many thousands of pounds of clams are wasted that way but it is probably a very, very sizeable number of clams.

Another result of the openings and closings policy is that there is a perception by the public that the fishery is in jeopardy. We have seen through statistics that harvests have been going up but I think that the public perception is that harvests are going down. I think that our fishery probably is in some sort of jeopardy but the perspective that the public has is different than what we have. I think that we need to take a look at the whole province when we take a look at openings and closures. We may try to solve a problem in area 14 by opening it or closing it or the same thing in area 13 or 15 or whatever, but we don't always consider what happens to the area right next to it and if we have too many areas closed then the whole industry converges on one small area. We have had this kind of thing happen out in Tofino. The transient diggers moved out to Tofino and as a result, all the local diggers are now out of work for the rest of the winter because all the

clams are gone. The point that I am trying to make is that the best intentions of managers do not always result in the optimal management of the fishery. We don't know all the answers either but we would certainly like the opportunity to sit down with D.F.O. and other agencies and be involved in the development of some of these policies.

Question : I would like to address my question to Mr. Rick Harbo, Fisheries and Oceans. I think you should be aware that many people are frustrated because the Department of Fisheries and Oceans has been reluctant to take input from the people who are most affected by the situation, the harvesters. The harvesters, I think, universally believe that this resource is not being managed properly. You believe that because you have an increased flow of product the resource is in good shape. I speak with a perspective of an ex-harvester who stopped harvesting clams because beaches where I used to be able to harvest 300-400 pounds of clams a day, today will yield no more than 50-100 pounds of clams per digger. That is a universal fact and I think if the Department went out and canvassed the harvesters, asked them what was going on, they would find that this has happened. The effectiveness of your conservation policies will only be to the degree of enforceability.

You have a size regulation. Harvesters will tell you that over the years, there have been certain buyers who have consistently bought undersize product. The enforcement of this regulation has been minimal. You talk about a $5,000.00 maximum fine. I would suggest to you that this fine amounts to only a license fee for buyers who are willing to buy clams that are undersize. If you took the total enforcement impact of any fines or loss of product to buyers who have bought undersize clams and you took that percentage of total profitability of that trade, you would find that they are paying a minuscule percentage of profitability. What this level of fine amounts to is just a license to traffic in undersize clams.

I can tell you from my own experience that undersize clams are taken from beaches. I have been on a beach where many clams were just a little undersize. When I came back in three or four months, expecting that they will be harvestable, I found that someone else had been there in the interim, harvested the undersize clams and sold them. There are beaches that you are hoping to control by general closure but the fact is that what you are looking at are pieces of paper. I would suggest to you that if the people who are working at making these decisions, were there with a fork on the beach and actually had a look, then they would be aware that we are working with a threatened resource. Soon we will see a reduction in clam landings and a lot of people who are now making a living at it will do the same thing as myself, that is retire and do something else. I guess this is a statement rather than a question but the statement leads to a question. Why is it that the Department keeps itself in this

ignorant state?

Mr. Rick Harbo: The Department has initiated an Intertidal Fisheries Advisory Committee, and there are clam harvesters on the committee. The only clam harvesters that have organized have been a small group in Lund, but we do have a process that harvesters are involved in. Other representatives include members from the British Columbia Oyster Growers Association and from the B.C.I.C.P.A.

We have established a limited number of clam surveys at Savary Island, Nanoose Bay, Gabriola Island and Clayoquot Sound.

But yes, I admit, the clam fishery has been loosely regulated. It is one of many fisheries we have to deal with. The resources, the people are not there to do all the work that you suggest. We put in budgets every year to do clam surveys and they often don't receive funds. Dr. Bourne also submits proposals to investigate clam culture and undertake clam surveys. They also don't get funded. I agree that a management plan is only as good as the resources that we have to develop it and enforce it and those resources are pretty slim.

LEASE OWNERSHIP & TRESPASSING - FEDERAL ROLE

Ms. Frances Dickson, Department of Fisheries & Oceans

A lot of what I am going to say may have already been said in one fashion or another, so my talk will be mainly a synthesis of some of the questions and answers you have already received.

The topic of my talk is the federal role in clam culture. The Department of Fisheries and Oceans (D.F.O.) views aquaculture as a critically important component of all commercial fisheries and is committed to its development in conjunction with continued maintenance of the wild fishery. As you know, the Department and the Ministry of Agriculture and Fisheries recently signed a "Memorandum Of Understanding" (M.O.U.) which was designed to recognize the respective roles of both governments. It was also designed to reduce the overall administrative and legal burden on the industry. Part of this agreement is the move to establish one stop licensing and leasing of commercial aquaculture developments in the province.

The provincial government is the agency responsible for the licensing function. D.F.O., therefore, is part of the overall referral process for clam culture licensing in B.C. The federal Department of Fisheries and Oceans supports the orderly development of a clam culture industry in the province and recognizes that there are many benefits that are associated with clam culture as opposed to wild fisheries. These are controlled harvesting, continuous market supply with potentially greater prices to both processors and fishermen, greater productivity from the tenured area and predator control. As well, clam harvesting on a farmed operation can be managed to minimize impacts on upland residents and high population density areas to solve some of the problems currently being encountered with respect to trespass, sleep disturbance and refuse disposal. These are problems causing criticism of the current clam industry.

Now I'll give a brief overview of the various branches within the Department that have a role in clam culture.

The Biological Sciences Branch has recently organized an Aquaculture Division and the Chief of it, Mr. Terry Tebb, has the overall responsibility for research in aquaculture. The Science Branch also provides health diagnostic services for clams.

The Inspection Branch must inspect and ensure safety and wholesomeness of all cultured clams exported from the province. It also conducts the mussel watch program to monitor the paralytic shellfish poisoning (P.S.P.) blooms which Mr. Rudy Chaing explained to you.

Fisheries Branch, to which I belong, is responsible for fisheries and habitat management and enforcement for all fisheries regulations. Fisheries Branch also has an Aquaculture Division in our Vancouver office. It is headed up by Mr. Ron Ginetz. As well, field district and sub-district offices are scattered throughout the province. It is to the sub-district office that your clam aquaculture application will be

referred by the responsible Lands Office.

The Clam Management Plan, which Mr. Bob Cox is going to talk about, has been designed in such a fashion that it will normally supply all of the information that Federal Fisheries will require in order to assess a clam culture application.

As I mentioned earlier, the Department manages the wild clam fisheries in B.C. and clam culture must be conducted in such a fashion that it complements the wild fishery which is one of the most important shellfish fisheries in this province. As Mr. Rick Harbo mentioned earlier, in 1987 the wild clam fishery was the most valuable shellfish fishery in B.C. and as such, it provides a lot of income to fishermen and processors.

Our Department and the Ministry of Agriculture and Fisheries have been working together on developing a joint policy paper on clam mariculture. This joint paper has not yet been finalized and we are looking towards this workshop to possibly provide us with some advice and guidelines which could be incorporated into it. The two governments agreed to work together on a clam mariculture policy for the province as a result of the agreement which was reached on clam harvesting and oyster tenures, however, there are two critical areas which have not yet been satisfied with respect to clam culture before it can fully proceed in the province.

Agreement must be reached on what actually constitutes clam culture as opposed to just clam farming or harvest of wild clams. Agreement is also required on the accepted level of each culture method that must be achieved. This is important because when a clam culture operation is licensed wild beach will be alienated from the common property resource and we have got to be assured that the clam culture operation for that leased property is going to provide significantly greater returns to the province than what can be achieved through a wild harvest. So what we have to do is to arrive at some kind of agreement on the means that clam culture will be achieved. This must be a measurable method which can include such things as beach enhancement, seeding, methods of increasing natural recruitment and predator control. From the Department's point of view, it is not sufficient to merely harvest a beach in a rotational fashion and rely solely on wild recruitment to seed that beach. We don't feel that this practice would be sufficient justification to alienate a beach from the common property resource.

Clam culture is difficult to assess because a large component of culture production is attributable to the wild sets and these clams have been traditionally harvested in the wild fishery. As Dr. Neil Bourne pointed out earlier, we have been unable to determine in Washington State exactly how much of their clam production comes from wild sets as opposed to seeding and it can vary from 5-30%. So what we have to do is to come to some agreement on the level of seeding that should be required. This workshop is a good opportunity for you to have input in helping us decide what these measures should be.

Site selection for clam culture is the area which most concerns the Department. At present, there is an agreement that applications for

clam aquaculture will be approved provided that they are not located on native food fish beaches, commercial or recreational beaches and provided that culture operations do not destroy valuable fish habitat including areas of eel grass beds that are used for herring spawn for example. Applications for clam aquaculture would also not be approved for beaches that front on Indian Reserves unless the application was from that Indian Band. This means that at the present time, anyhow, the best opportunities for clam culture are probably in the Strait of Georgia with existing oyster tenure holders who have suitable clam substrate or with native Indian bands.

The Department tries to discourage farmers from starting operations in areas which traditionally encountered large closures due to P.S.P. Clam culture, at this time, will not be approved for the north coast area, that is, areas of the province north of Cape Caution due to the fact that there is a year round P.S.P. closure in place.

In addition, in order for an application to be approved for clam culture, it is necessary that there be an up to date water quality survey for the area. These are done by the Department of Environment. At present there are four licensed clam culture operations in place in the province but I would like to point out that in the last couple of months the Department has reviewed approximately half a dozen applications for clam culture and we haven't objected to a single one. So despite the fact that there are some siting restrictions, there are obviously beaches which are available and suitable for clam culture. So while it may be easier to get approval for clam culture if you are an oyster farmer, it doesn't preclude opportunities for other beaches in the province.

Once a clam farmer is licensed, they will be subject to the same P.S.P. closures that apply to all beaches in the area. As well, all the cultured clams will have to be processed in federally registered shellfish plants. If a clam farmer wants to improve the beach on their licensed area, they will have to get prior approval from the Department in order to assure that there is no disturbance to fish habitat; these improvements must be preauthorized by the Department. Because clam culture sites may rely on seeding from wild beaches and because this can be a significant part of the production for that licensed clam farm, current minimum size limits will apply to both cultured and wild clams. This is because it is felt that the licensed clam farmer is receiving seed from wild beaches and they in turn should be providing some seed to surrounding wild areas.

In summary, the Department supports clam culture for sites that are not important food fishing, commercial or recreational beaches and that do not alienate important fish habitats. Local sub-district fishery offices should be approached as soon as possible in the site selection process. We really encourage you to do that so you don't get too far ahead in your planning process if your site is a problem to us. Because clam culture will exclude existing wild harvest by commercial fishermen and recreational fishermen, it is important that clam culture production must significantly exceed wild production for that given beach. Clam culture has the potential to offer many benefits to the fishing industry in this province and once a clam culture industry is successfully

developed, there will no doubt be pressure on the Department to examine our current site selection guidelines which many of you, no doubt, find somewhat restrictive.

LEASE OWNERSHIP & TRESPASSING - LEASE APPLICATION

Mr. Doug Barry, Ministry of Crown Lands

I work for the provincial Ministry of Crown Lands and my talk today is about lease applications and to a minor extent, regulations regarding those leases.

The Ministry of Crown Lands administers the publicly owned Crown land and submerged land in the province through the legislative authority of the Land Act. We manage and allocate these lands through consultation of provincial, federal, public agencies and the public to provide economic, environmental and social benefits for British Columbians. We try and balance conflicting interests so that the land is put to it's best possible use at a fair return to the people of the province.

What do we offer? If you wish to utilize a portion of land to develop a business opportunity such as a tourist resort, marine, pulp mill or aquaculture operation, you have to obtain permission from the owner of the property and in this case, in the province of British Columbia, Crown land is administered through our Ministry.

In British Columbia we have had some court cases to decide ownership between the province and the federal government and, for the most part, it has been ruled that the intertidal land between Vancouver Island and the mainland up into Queen Charlotte Sound Strait is owned by the province. Thus, for the most part you have to deal with us for tenures for aquaculture. The only exception would be a federal harbour and there is little chance of getting into aquaculture in Prince Rupert or Vancouver Harbour.

If you are on land, we can offer a fee simple or purchase as well as leases, licenses, easements and rights of way but when you get to the water, we prefer not to sell the water. We like to keep it as a provincial resource. So what we offer there are leases, licenses and for hydro lines, we issue rights of way.

How do you locate vacant Crown land? Most of you are familiar with the water and if you are a boater, you can see which land isn't being used. This would be a pretty good indication of where the tenures would be. If we have issued a tenure, that area is supposed to be diligently used whether it be a marina or for culture of oysters or clams. If it is log handling, it is supposed to be used as well. Being on site you can have a good idea about where the tenures are. If you want to find out a little more information as to the availability of land, Ms. Frances Dickson has indicated that her fishery officers also know a lot about the area and where tenures are. The local government in the areas know where tenures are as do the local conservation officers but ultimately we have them all plotted on maps in Victoria. We are hoping that through computerization these will be more readily available. On Vancouver Island you would deal with the office in Victoria. We have eight regions in the province and depending on the area you would deal with the local Lands office to get the most accurate status of land and submerged land.

If you are dealing with aquaculture, we strongly suggest you discuss it with the Ministry of Agriculture and Fisheries.

We generally have two ways to acquire a Crown land tenure. If we have done a planning study in an area to identify the best uses for land and specify areas for specific uses, we generally allocate land in those areas by public competition. Valuable tenures, like oyster leases, that have expired or have been dropped can be put up for a form of public competition so that the general public has an opportunity to acquire the site.

Usually, however, Crown land is made available by direct application. The first step is to formally make application. We have a procedure for application that involves the steps on Figure 10.

First, you post the application on site, define on a piece of paper exactly what you are applying for and tie it into a legal description so that anyone that wants to know can find the area. Having completed that, take the application, or send, it to the Ministry office. We have a $50.00 application fee and we must have a plan showing what you are proposing. We acknowledge the application. We send referrals out to different agencies; generally for bottom culture they would be local government, Department of Fisheries and Oceans, Fish and Wildlife, Ministry of Agriculture and Fisheries, Environmental Protection Service (due to closures) and others if they have indicated interest in the past. We request that the application be advertised by the applicant by placing the staking notice in the ground to let the people who use the area see it and know that there is an interest. They can come to us and ask about it or indicate their preference or objections. We also ask that you advertise it in the local papers and we give directions on how to do that. What it amounts to is that you advertise locally once a week for two weeks and once in the B.C. Gazette to advise the people of the area what you are intending to do so that we can solicit input from other users who may have an interest in the area.

We do a field inspection to personally view the site and look at other uses. We prepare a report and then, if it is favorable, we offer you a commitment. The preliminary documents that haven't been signed are an offer. We ask you to read it over and, if you agree to what we have offered for area, etc., we ask for a documentation fee, rent (minimum of $200.00 per year), liability insurance which we ask for in case anything is put on the beach (you are responsible if anyone gets hurt on the beach area) and a performance bond if you are placing structures on the land so that the province wouldn't be asked to remove any derelict structures that are left there. You sign the three documents, have them witnessed and return them. If everything is done properly, we sign them and return one to you which becomes your formal authorization to use the area. That document includes the "Production Plan" or "Development Plan" which we attach as part of the document and it specifies what you are going to do. The complete process is presented in Figure 11.

The next question is what types of tenure are available. The first one is an INVESTIGATIVE PERMIT (Figure 12). These were put out, for the most part, for fish farmers but we have had some people in the shellfish

industry who wanted to go in and look at an area for up to a year, do some water quality testing, check it out and see whether an area was suitable for developing an aquaculture enterprise. These tenures do not allow anything to be put on the area such as structures or seed stock. It is only to test the area for water quality, etc. This gives you one year in advance to hold an area while you are testing. At the end of one year, if you don't apply, the permit is cancelled and the area is open for anyone else that may wish to apply.

The second form and the one we use for people who are developing an aquaculture industry, marina, log handling area or even a pulp mill is a LICENSE OF OCCUPATION (Figure 12). The province gives you the right to use an area for the purpose specified in the document. In this case, it would be to grow clams. Those are generally up to a ten year term. They aren't replaceable. You can't just renew them because some of the terms and conditions may change in ten years time. We do, unless we've had severe opposition to an area, generally replace one document with another as long as you have been using an area, providing production returns and reports to the Ministry of Agriculture and Fisheries and we don't see any reason why you shouldn't continue with the operation.

The third tenure and the one that gives you more control is a LEASE (Figure 13). This allows for the development as specified in the "Development Plan", as do all of them, but this one allows for exclusive possession. You can enforce trespass on this one more easily because you have that right of exclusive possession. Some of you may be in the oyster industry. You know that where there is public access along the beach, we will try to exclude that area from your lease or we may put a proviso to allow public access, walking along a certain portion of the beach. Where possible, we try and specify it. If not, it can get into a bit of a problem if a picker comes in and says that he is using it. He is the public but what we are talking about pedestrian access rather than using the site.

In summary, aquaculture is a rapidly expanding industry which is encouraged by the provincial and federal governments. A considerable portion of our workload is associated with providing assistance to potential aquaculturists, applicants and existing tenure holders who are looking at expanding into the clam culture. We are there to serve you and look forward to being able to provide land tenures for your business operations where the land is suitable.

Question : I would like to ask about the basic right of access?

That is one thing I didn't get into in detail but on some of our tenures where there are no improvements or structures that would impede the physical access to the beach at any time, or to the upland parcel at any time, no riparian ownership or consent would be required. What you have to realize is that if the owner is going to drag a boat through there all the time, we can usually put a clause in the document that says subject to his access because in a lot of cases, they don't use it. They do legally have a right to go across. Where you are stacking things up on the beach, you require the owner's consent. You have to leave the beach in as flat a position as possible. If you are taking equipment out there like a tractor, that would be deemed an

interference.

Question : Don't you require upland consent when you apply for off bottom culture?

That is correct. The difference is that I was catering my talk to clam culture which I understood was basically using the bottom. When you are dealing with off bottom culture, fish farms or anything like log handling, you have to go beyond the zero tide and the court has indicated that you have to leave reasonable access for a reasonable size boat. Now the province and our Ministry has interpreted that to mean access for (we're being conservative) say a forty foot boat. There are a lot of boats that are smaller, but there are some that are larger so what we've said is that usually that will draw maybe three or four feet and if you can leave say minus three foot tide plus forty feet out, they usually have enough room. That is just a ballpark figure of what we are looking for and what we feel will be a potential infringement of an owner's riparian right.

1. Application to Ministry of Crown Lands

2. Acknowledgement

3. Referrals

4. Advertising - Done by Applicant

5. Field Inspection

6. Report

7. Committment Letter

8. Final Document

Figure 10: Aquaculture application process for land tenure.

BOTTOM CULTURE AQUACULTURE APPLICATION PROCESS FOR LAND TENURE

APPLICATION POSTED ON SITE

↓

APPLICATION TO MINISTRY OF CROWN LANDS
Includes: $50.00 Application Fee
Development Plan

↓

ACKNOWLEDGEMENT → Applicant
REFERRALS → Local Government
Department of Fisheries and Oceans
Ministry of Environment: Fish and Wildlife Branch
Ministry of Agriculture and Fisheries (Development Plan)
Environment Canada: Environment Protection Service
Others if necessary

↓

ADVERTISING (Done by Applicant)
Local Paper (2 times)
B.C. Gazette (1 time)
Proof Returned to Crown Lands by Applicant

↓

FIELD INSPECTION (Done by Crown Lands)

↓

REPORT

↓

COMMITTMENT LETTER (Preliminary Document)
Requirements: $150 Documentation Fee
$200 Rent (Minimum for First Year)
Liability Insurance ($ 1,000,000)
Performance Bond - if needed
Sign 3 Documents and have signature witnessed
Return Signed Documents and Specified Requirments to Crown Lands

↓

FINAL DOCUMENT
Documents signed by Crown Lands and tenure formally issued.
Formal authority to use Crown land

Figure 11: Bottom culture aquaculture application process for land tenures.

INVESTIGATIVE PERMIT

Term - Up to 1 Year to determine if site is suitable for commercial culture and to complete Development Plan

- No Structures or harvest permitted

Cost -

$ 100.00	(Shellfish)
50.00	Application Fee
50.00	Documentation Fee
$ 200.00	TOTAL COST

LICENCE OF OCCUPATION

Term - Up to 10 years

- Allows for development as specified in development plan in document

- Possession for purpose specified in Licence only

Cost -

$ 50.00	Application Fee
150.00	Documentation Fee
	Advertising
	Insurance
	Performance Bond - If Necessary
200.00+	Rent plus 1% of land value for years 1-5; 4% of land value for years 6-10; Minimum Rent $200 Annually

Figure 12: Investigative permit and licence of occupation forms of tenure.

LEASE

Term - Up to 30 years

- Allows to for development as specified in Development Plan in document

- Exclusive possession for specified term

- Leaseholder can enforce trespass provided lease document grants full control - sometimes we allow pedestrian access along beach

Cost - $ 50.00 Application Fee
150.00 Documentation Fee
Advertising
Insurance
Performance Bond - If Necessary
Survey
200.00+ Rent 1% of Land Value for years 1-5
5% of Land Value for years 6-end
Minimum Rent $200 Annually

Figure 13: Lease form of tenure.

LEASE OWNERSHIP AND TRESPASSING - MANAGEMENT PLANS

Mr. Bob Cox, Ministry of Agriculture and Fisheries

The are a couple of points that I want to get across. One of them is that I take exception to some of the things that were said this morning. One of them was that you can't get good clam culture ground. Certainly we hear it from the other end, from the harvesters, that some of the best clam culture ground is tied up in oyster leases so I think there is a large amount of good clam culture ground out there that has not been applied for at this time. I have some question as to why people haven't come forward because we have consistently indicated to people that they have that ability to apply for those areas. Assuming that people want to do that, want to look at other areas, then basically what we require is a management plan. We don't really have a "Clam Culture Plan" per se. We tried to incorporate a number of things into a revision of the Marine Shellfish Farm Development Plan (M.S.F.D.P.) that was done earlier this year to address the question of clam culture. For those of you who are not in the business, the plan is a five page document broken down into a number of areas dealing with biophysical site characteristics, potential site conflicts, production proposal, etc. (Refer to Appendix IV).

We have a long history of oyster culture in B.C. People within the Aquaculture and Commercial Fisheries Branch have experience in oyster culture and I think we can probably look at any plan and have a good idea as to it's viability. We simply do not have that background with clam culture right now. I am here today to take input as to what people feel should be included in the plan. We will endeavour to work with Crown Lands to have the plan modified to make it more responsive to the requirements of a clam farmer.

With site suitability there are a number of things we are after including: exposure to winds and waves; annual tidal range; water temperature and salinity; etc. Can we identify potential problems from a locational standpoint that would affect you? One area that we recently updated was the identification of known predators. We don't really know the effect of predation on clam culture. I think we need to look at that a little more closely. For example what does heavy crab predation mean in terms of clam culture? How will that restrict seeding and operational parameters? We really can't answer that right now except to say that it probably is not good.

With respect to growing water certification, there has to be a current fecal survey indicating the status of water quality. You need to prove water quality standards for any type of bivalve shellfish culture so that's something that you are going to have to make sure is done. If the area has not been surveyed, there may be some possibility to get in a look at the site. Mr. Doug Barry mentioned Investigative Permits (I.P.) for clams but what he didn't mention is that the I.P. doesn't allow you to actually go and put organisms on site. From a shellfish standpoint that the only way you're really going to prove a site is to put some clams or oysters out there and see how they do.

If your application is not in "open" or "approved" water, then you are

going to have to arrange to get that testing done. The resources have been increased for Environment Canada and we can get you on the list but it still may take up to a year to get on site testing done. You can take water quality samples yourself, and have them processed at a private lab to at least somewhat assure yourself that the water quality meets the standards. I would think that if you wanted to do that you should consult with Mr. Bruce Kay so that he can advise you of the best time and way of doing that. This still does not eliminate the need for the official surveys carried out by Environment Canada.

Paralytic shellfish poisoning (P.S.P.) - I am not going to discuss this too much. Anybody in the bivalve shellfish game is going to have to live with P.S.P. but certainly I think you can look at some of Mr. Rudy Chaing's information and gather inferences as to what the possible chances of your area being contaminated on a regular basis is going to be. Unfortunately, blooms cannot be predicted.

A section that was added to the plan this spring deals specifically with the description of beach substrate. We would like to know what is there in terms of substrate. You are all very much aware that there are substrate preferences by Manila clams in terms of types of material. We are more than willing to sit down with people and go through the plan and assist you in sorting it out so when you come in, you don't have to get into a back and forth dialog which could delay approval.

One of the areas where we run into some problems is in defining production. I know we are going to run into some problems with this and hopefully we'll get some feedback in the next two days in operational and production characteristics. What is the clam farm going to look like in terms of operations? We have some indication from the U.S. but as we've been told earlier, it is a different system down there. What is full production on a clam tenure? We don't really know that yet. One of the ways we feel we can determine that and one of the things we are going to ask for in this plan is for a preliminary on site resource investigation. In other words, we want to know what is there, what exists today. Are we looking at an area that doesn't have any clams, that has five pounds per square meter or ten pounds per square meter and how are we going to relate that to a requirement that the Ministry wants to see in terms of culture. Are we going to ask people to double that? If it is two pounds per square meter, doubling it to four probably isn't economical. Do we have a sliding scale where if it's two pounds and everything else appears suitable, you should do eight and if there's ten pounds there, it's closer to maximum. Do you do 50% and have to produce fifteen pounds? I am being honest right now. We really don't know what we are going to ask for. I certainly hope we can get some feedback and sit down and clarify those things because I certainly expect we are going to see increases in applications for clam culture, not just as a result of this meeting but due to a pent up momentum that is out there. I should also add that the on-site resource study is going to have to be done by a qualified independent person. We want to see someone else out there that is going to do an independent survey. There is going to be some bias, if it is done by the person applying for the tenure.

A lot of conflict from other coastal resource uses have been alluded to today and I am not going to get into any great detail on those. I think

the one that has been hammered home is the fishing conflict with the existing commercial clam fishery and that is something we certainly hope we can work out between ourselves, the federal government and industry. I strongly urge people that are going into the business that the best thing that they can do is make sure that they have a manageable operation on a sound basis to prove that the industry can be viable here. That is going to put pressure on the regulatory agencies to open up additional areas to culture in the future. We have one industry in B.C. that has been going for seventy years and I am not really sure whether we can use that as the basis for saying we should open up more areas for clam culture because I don't think the oyster industry as a whole in the past has been a particularly good role model. A lot of people who have leases are not using them and I am not just talking about people who started necessarily growing oysters in the last five or ten years. It is throughout the industry and certainly something we don't want to see happen with a new and developing industry is for beaches to get tied up and not get used. It is certainly one of the things that this plan is aimed at doing, to some degree ensuring that there is reasonable use of the extremely limited resource out there in terms of suitable areas.

What does clam culture represent? If someone submits a Development Plan and there is no indication that they are going to do anything except turn the beach over once a year, is that sufficient? It is unlikely we would accept that as clam culture. We have to be assured, given the rarity and value of that resource, that it is going to be well used if it is tied up for clam culture and I won't keep you from lunch any longer except to indicate that I will be around for the next day and a half if anybody has any questions or thoughts they would like to put forward on this subject.

Question : I have a section of my oyster lease that could support clams, can I apply for a clam culture lease?

There is a significant amount of beach that is already alienated for shellfish culture, basically oysters, which is exceptionally good beach for Manila clam culture as well. A lot of the people, in fact most of the people as far as I am aware of, have not applied to amend their use of that area to include clam management and certainly we have indicated that is a viable use of that land and that would be acceptable. My understanding is that would be acceptable to the Department of Fisheries and Oceans. Ms. Frances Dickson and Mr. Rick Harbo were talking about are areas that are not currently alienated. When we are looking at clam culture we must ensure that it does not impede upland owners access and egress. It is only when you start to put structures on the beach that it becomes affected.

Question : How can I control trespassing on my lease by tourists and other people?

I think to some degree that is a matter of common sense and I don't think as a lease holder you stand out there with a shotgun and keep every tourist that just happens to wander along the beach off. Certainly if it is an area where you get a fairly high pedestrian traffic, whether it is tourist or local, you have to try and keep them

from interfering with your ability to make a living. There is a fine line and I think to a large degree with local people and with tourists that a lot of the existing growers have reached a reasonable accommodation. I think the major conflicts are between the commercial diggers and culturists.

Question : I would just like to ask Mr. Barry about the basic right of access?

Mr. Doug Barry : That is one thing I didn't get into in detail but on some of our tenures where there are no improvements or structures that would impede the physical access to the beach at any time, or to the upland parcel at any time, no riparian ownership or consent would be required. What you have to realize is that if that owner is going to drag a boat through there all the time, we can usually put a clause in the document that says subject to his access because in a lot of cases they don't use it. But they do legally have a right to go across there and that is a law they have but where you are stacking things up on the beach, you can't do that without owner's consent because you are interfering or causing any interference with them. You have to leave the beach in as flat a position as possible. If you are taking equipment out there, like a tractor, no! That would be deemed an interference.

PROCESSING THE PRODUCT FOR MARKET - PROVINCIAL REGULATIONS

Mr. Charlie Twaddle, Ministry of Agriculture and Fisheries

INTRODUCTION

The provincial Ministry of Agriculture and Fisheries is responsible for administering the British Columbia Fisheries Act, Fish Inspection Act and accompanying regulations. This legislation gives the government the authority to regulate the fish processing and fish buying sectors.

While the Ministry of Agriculture and Fisheries license all fish processors, buyers and fishermen vendors, the inspection of these facilities is shared with the Provincial Ministry of Health. Health Inspectors evaluate all fish processing plants and inspectors from Agriculture and Fisheries inspect fish buyers and fishermen vendors.

REQUIREMENTS FOR THE HARVESTING OF BIVALVE SHELLFISH

Before shellfish can be removed from the harvest site, they must be tagged. Tagging is important as it allows the movement of shellfish to be monitored. If problems are found at the processing plant, proper tagging will assist in locating product origin.

Tags are constructed of waterproof paper. Pens with indelible ink should be used. The harvesters name, species, Fisheries statistical area and sub-area and the date of harvest is required on the tag.

Section 54 of the Fish Inspection Regulations outlines tagging requirements (Figure 14).

PROCESSING OF PRODUCT

The federal Department of Fisheries and Oceans has jurisdiction over facilities processing fish for export. Fish plants processing product for domestic consumption are the concern of the province. Since 1986, however, provincial regulations have required that all bivalve shellfish, including domestic stock, must be processed through a federally registered fish processing plant. The province does not have the resources to adequately sample and monitor the movement of shellfish. To ensure product wholesomeness and safety to the consumer this regulation was introduced.

Section 12 (1.1) of the Fish Inspection Regulations requires that, and I quote : " No person shall sell or attempt to sell any harvested bivalve molluscs unless the molluscs were, before the sale or attempted sale, processed in an establishment that at the time of processing held a valid certificate of registration issued for that purpose by the Department of Fisheries and Oceans (Canada). "

MOVEMENT OF HARVESTED SHELLFISH

Product reaches the processing facilities in one of two ways. By a fisherman transporting his own catch or by a licensed fish buyer.

1) Transporting Own Product

A fisherman may transport his own product. There is no provincial fish buyers license needed for this. There are, however, requirements found in the Fish Inspection Regulations outlining standards that must be met and kept while fish or fish products are transported to market.

2) Transport by a Licensed Fish Buyer

A Fish Buyers License is required when the product is transported by other than the fisherman. By definition, the word "buying" includes more than a cash transaction. A provincial Fish Buyers License is required when one or more of the activities below occur.

The Fisheries Act Interpretation section defines a fish buying station as follows:

(a) a building, structure, machinery, appurtenance, appliance and apparatus;

(b) a vehicle; and/or

(c) a vessel, scow, barge or float

within the province or its coastal waters, with or without installed propulsion machinery, used in the business of buying, collecting, assembling, eviscerating, transporting, conveying, packing or carrying fish direct from the fisherman.

Compliance standards for units buying fish are outlined in the Fish Inspection Regulations, Schedule E. No buyers license will be issued until an inspection has been conducted to confirm the buying station is in compliance with these requirements.

A licensed cash buyer is responsible to ensure that "fish slips" are properly filled out. Fish slips are used by the federal Department of Fisheries and Oceans to monitor and regulate wild fisheries.

Section 20, Part 7 of the Fisheries Act Regulations are stated in Figure 15.

Current regulations do not require an individual to obtain a buyer license when buying wild oysters or cultured, farm raised, product. These regulations are currently under review.

OTHER ENFORCEMENT AGENCIES

In addition to the provincial Ministry of Agriculture and Fisheries, there are a number of federal and provincial government agencies that may enforce the British Columbia Fisheries Act, the British Columbia

Fish Inspection Act and accompanying regulations. The most commonly encountered are listed below.

1) The British Columbia Ministry of Environment

   Conservation Officers appointed under the Wildlife Act

2) The Department of Fisheries and Oceans, Inspection and Special Services Branch

   Federal Fisheries Inspection Officers

3) The Department of Fisheries and Oceans, Fisheries Branch, Enforcement Unit

   Federal Fisheries Enforcement Officers

Officers representing these agencies hold ex-officio status by virtue of their appointment.

Records of transactions with fish suppliers

20. A person holding a licence under Part 3 of the Act who is required by section 20 (2) of the Act to keep a record of transactions with fish suppliers shall

(a) keep the record in the appropriate forms set out in Tables 1 to 4 of Schedule VI,

(b) report in the record all fish received from fish suppliers at the time and place of receiving the fish, and

(c) submit the appropriate froms set out in Tables 1 to 4 of Schedule VI on a weekly basis by mailing the forms to the Department of Fisheries and Oceans (Canada), 1090 West Pender Street, Vancouver, B.C., V6E 2P1, or by delivering them to that department by another method, retaining a copy of each form for the licensee's own records.

[en. B.C. Reg. 3/86, s. 2.]

Figure 14: Section 54 of the Fish Inspection Regulation.

54. (1) A person who harvests bivalve molluscs for commercial purposes shall, before removing the molluscs from the harvest site,

(a) place them in containers, and

(b) affix to each container a tag legibly and durably marked to indicate

(i) the name of the harvester,

(ii) the species of mollusc in the container,

(iii) the area and sub-area of harvest, as set by the Department of Fisheries and Oceans (Canada), and

(iv) the date of harvest.

(2) No person shall

(a) deface or alter a tag affixed to a container under this section, or

(b) remove a tag affixed to a container under this section until the molluscs

(i) have been received for processing at an establishment that has a valid certificate of registration issued by the Department of Fisheries and Oceans (Canada), and

(ii) have been adequately marked for identification by a means other than the tag.

(3) The person in charge of an establishment who receives molluscs in containers to which tags have been affixed under this section shall ensure that the information on each tag is recorded and retained for at least one year after the date of receipt.

[en. B.C. Reg. 166/86, s. 2.]

Figure 15: Section 20, part 7, of the Fisheries Act Regulation.

PROCESSING THE PRODUCT FOR MARKET - FEDERAL REGULATIONS

Mr. Rudy Chaing, Department of Fisheries and Oceans

For the bivalve industry we have a Bilateral Agreement between the United States Food and Drug Agency (U.S.F.D.A.) and Canada that was signed in 1948 to assure each nation that the marketing of bivalve molluscs between the two nations was subject to the same set of sanitary criteria in terms of harvesting water, transportation and processing requirements. Basically to make sure that the product is safe and not contaminated.

One of the major concerns of course is paralytic shellfish poisoning (P.S.P.). How do you monitor the area? How do you know when to close it and how do you know when to lift the closure?

What are the rational for having such a stringent program for bivalve molluscs? Because they are filter feeders, bivalves will concentrate bacteria, contaminants and nutrients as well. This differs from fin fish because they are not filter feeders. With P.S.P., spontaneous outbreaks can happen unpredictably. What we have to do is to monitor the harvest area from time to time to make sure that when there are toxic blooms, we know about it and we can take action and respond to it. Given our huge coastline, the logistics of covering a remote area is very difficult.

The basic program criteria is that all bivalves must be harvested from "acceptable" and "approved" growing waters. It does not make any difference if the meat count of the clam or the oyster turns out to have a faecal coliform count of less than twenty. Bacteriologically the meat count is acceptable but if they were harvested from contaminated areas, we cannot sell those products. Since faecal coliforms are indicator organisms of sewage contamination an acceptable meat count does not preclude the possibility that pathogens are present in the bivalves if they were harvested from contaminated waters.

Section 6.1.B of the Fish Inspection Regulation puts the onus on the processor to satisfy the Minister that the bivalves were indeed harvested from approved growing areas and that they were handled and processed in approved facilities so that the product is not contaminated.

Proper product handling is the other major component of the program. Product can be mishandled by washing them in a contaminated body of water, hanging them right next to a boat or otherwise abusing them through processing in contaminated plants or when the water of the processing plant is unacceptable. All these practices can lead to contamination.

Communication is very important. It is critical that we can advise people in an affected area on a timely basis.

Under the Fisheries Act, we have two sets of basic regulations. One is the Sanitary Control of Shellfish Regulations which says that if a body of water is deemed unacceptable because of contamination, the Minister

will describe the boundaries of the area, authorize signs to be posted and declare that to be a contaminated area.

The other one is the Pacific Shellfish Regulations. It allows toxic areas to be closed and prevents people from harvesting in closed areas.

While the Fisheries Act deals with the harvesting, handling and conservation of products, the Fish Inspection Act deals with the processing of products that have been harvested. The Canadian Food and Drug Regulations will set criteria and standards. The Department of Fisheries and Oceans will enforce the standards.

The requirements for processing plant certification comes under the Fish Inspection Regulations. The processing of all fish or shellfish products must be done in registered processing facilities. For bivalve molluscs, there are various types of certification such as Shucker/Packer and Shell Stock Shipper. The type of certification depends on the kind of facility a processor has and what kind of final product he wants to market.

The basic requirements are: sanitary water supply; proper walls; proper floors; ceilings; and processing equipment so that the processor can maintain a sanitary environment where the product will be processed. Back siphoning is another concern. Unless there are back flow preventers in the water tap, it is possible that when a worker submerges a water hose in a tank full of fish, contaminated water may be sucked back into the system.

Question : Is it reasonable for a digger or grower to wash his clams in the same water he is getting his clams from?

It is acceptable for them to rinse the clams in those waters in which they are harvested assuming the water is acceptable. In other words, you are not digging in a closed area. We do not, however, consider that as processing. We consider that as part of a good harvesting practice. We will not accept the excuse that well " if I can rinse the clams in a body of clean water, there is no other processing required ".

Question : I understand they can be washed, but do clams themselves contribute to the faecal count?

To the best of my knowledge, clams themselves do not produce fecal coliforms.

Question : Do fish contribute to coliform pollution?

Fish are not warm blooded animals so I don't think they will.

PROCESSING THE PRODUCT - DEPURATION/PURGING

Mr. Bob Cox, Ministry of Agriculture and Fisheries

First of all what I would like to do is go through a few definitions to clarify exactly what we mean when we talk about purging and depuration.

Purging is the act of holding shellfish in clean water thus allowing the shellfish to purge themselves of sand and other debris so that the product has greater market appeal. Anybody that has gone out and dug clams and then not allowed them to clean themselves out in a bucket of seawater and has lost a couple of fillings on a piece of sand or grit is probably well aware of what I am talking about. Purging is not really providing any treatment to the animals, you are just allowing them to clean themselves up.

When we start talking about depuration, then we are talking about attempts to remove fecal coliform and other bacteria to provide a product which is acceptable to the market in terms of the standards that Mr. Rudy Chaing and others alluded to earlier. There are really two types of depuration.

One can be called "natural depuration" but is more properly called controlled relaying where product is taken from a contaminated area and moved to areas with acceptable water quality. This happens in the oyster industry right now, using the clean water in another location to cleanse polluted shellstock to the level where they meet federal bacterial standards. Current regulations require that the product be held for fourteen days so you've got product tied up for quite a while before you can process and market.

The second type is "controlled depuration". Controlled depuration is something that occurs within a facility where "treated" water passes over the shellstock. There are a couple of methods of treating the water but they have problems. Basically what we are looking at is ultraviolet treatment of the water which kills the pathogenic organisms allowing the product to purge itself. Generally this has been found to occur within 48 hours. There is a shorter turn around time compared to relaying but capital costs are greater. Why are we talking about these processes? If I can have the first couple of slides they will give you an indication.

I use this to some degree for its humorous effect because what you see in the background is a sewage treatment plant and a large sign marking an outfall and posted to that, is notification of an oyster lease. This is one of those situations where the lease was in place before the Sewage Treatment Plant. We are going to have to learn to live with some of these problems. They are not going to go away and hopefully I'll explain to some degree how we can handle them.

Obviously you cannot directly harvest in these areas. This is a problem on the east coast and in Europe. We were recently told that contamination has been a problem in Japan and is now showing up in other areas. This is a problem we are <u>going</u> to have to learn to live with.

Just to give you some indication of how much area is actually affected, the total area closed or impacted by sewage outfalls in B.C. is almost 89,000 hectares (1,300 square km). Not all of these areas are directly closed but there is impact which will have some potential negative feedback if you want to go in there and try to culture shellfish. As Mr. Bruce Kay pointed out, contaminated sites are not all in prime growing areas but the numbers are continuing to go up and as much as we would like to get some of these areas open, it seems that for every one we get out we put five or ten more in.

At a recent meeting of the West Coast Shellfish Group in Reno which deals with these sanitary issues and helps set the standards, it was indicated that by the year 2000, in the continental U.S., 70% of the population is going to be within 50 miles of the ocean. Now I have a feeling that probably in B.C. we are already there or past it but those trends are there and they are going to continue. That is going to continue to have impact on coastal waters, most of it not generally favorable to shellfish culture and development.

Contamination is beginning to show up in product lots and processing plants. We are looking at some periods in 1988 when over 40% of the clam lots that were sampled didn't meet fecal standards. There is contamination out there and it is affecting product quality.

This is a photograph of one of the pages out of the old Tidal Water Sport Fishery Guide. They don't put this map in anymore but it is just to give you an indication, the red areas are areas that were under Schedule I Closure. This is 1984-85 and some of the closure areas, I think, were even too small to show up, (the red x indicates paralytic shellfish poisoning closures). This gives you an indication of the distribution of closure areas and certainly there are more in the gulf and in terms of clams, that works out to where approximately 80% of the production of clams is coming from, so the two activities are in conflict.

One of the points I was going to make was that we have to meet these rather stringent standards that Mr. Bruce Kay alluded to because of our Memorandum Of Understanding with the U.S. As everybody here that is in the business knows, the majority of our product goes south so we are going to have to make sure that we stick to those guidelines because certainly they have the ability if to shut the border down to B.C. product. How do we provide that top quality product to the market?

One of the ways is simply to grow them in clean areas. We still do have a lot of those areas. Purging, as I have already mentioned, is a relatively inexpensive way in some situations for providing a higher quality product. It will deal with the purging of sand and other grit, but not with fecal coliforms. There are two ways of doing it and I'll show you some slides a little later of one plant where, at present, the product is being purged internally. Once it comes inside a building you have to start meeting the processing guidelines in terms of potable water, etc. so it becomes a more stringent process to purge once you move the product inside a building, whereas outside pumping from approved waters is not quite so stringent. It is relatively inexpensive, but that is not an option that is open to everybody.

Controlled relaying is an area that we are into right now with oysters. In recent years, the Canadian program in terms of monitoring, (both Mr. Rudy Chaing and Mr. Bruce Kay through Department of Fisheries and Oceans (D.F.O.) and Environment Canada are involved) has been looked at very closely by the United States Food and Drug Agency (U.S.F.D.A.) and there have been a number of areas that were indicated as not meeting compliance and there have been a significant number of changes. One of the procedures which was not being followed closely enough to suit U.S.F.D.A. was the requirement for on-site monitoring or verification by D.F.O. whenever harvesting occurs in closed areas. Given current manpower constraints, a significant increase in requests to harvest from closed areas may not be able to be serviced. The point being made is that the U.S. agency is becoming much more stringent in the requirement for application of the standards and guidelines. They are not just coming down on governments and suppliers outside the U.S., they are also coming down as heavily within their own state. They are very concerned about providing clean, wholesome products. Assuming we are going to be able to take product from a closed area and depurate it, how can you go about doing that? What are the basic requirements?

I am going to go through material taken from Fisheries Inspection guidelines and I am not going attempt to go into any significant detail.

Chlorination is one way to purify water, but unfortunately chlorination can negatively impact the filtration rate of the shell stock. It will clean up the water but if the shellstock doesn't pump, it is not going to clear itself. So it does not really work.

Ozonation, which is production of 03 using an ion generator, and passing sterilized water over shellstock, will certainly sterilize the water. But to get the 03 levels within the water high enough to purify the product, it becomes toxic to the shellfish. Ozonation in live holding tanks in fish stores and restaurants has not worked all that well. This brings us down to ultraviolet (UV) light. This is the system that has been used in depuration, certainly since the whole question of depuration really blew up in the late 60's and early 70's. It is very straight forward to put a system together which will sterilize water although there are some people here that will admit that trying to put a system together that satisfies Fisheries Inspection is somewhat difficult. Here are some of the steps that are required to develop a certified controlled depuration facility. The initial points regarding the harvest site would also apply to controlled relaying. Before you even build a plant or siting a building, your harvest sites have to be suitable.

You cannot just harvest from any area. The harvest site has to meet the standards outlined in the U.S.F.D.A manual. Basically it states that the fecal coliform count cannot exceed 88 per 100 ml. As we saw before, the approved growing water is 14 per 100 ml so we are looking at significant increases but certainly there are a number of heavily contaminated areas that would not be acceptable for use of either controlled relaying or controlled depuration. The shell stock itself should not exceed 2300 fecal per 100 grams and again that's ten fold over the 230 fecal per 100 grams which you have to meet from approved areas. So it doesn't allow

harvest from every contaminated area but would open up a lot of areas which are now marginally contaminated.

Obviously there should not be any chemical contamination in the water. The guidelines indicate that determination of presence of these contaminants is the responsibility of the applicant and you have to set up a program with D.F.O. Inspection to insure that your harvest site meets acceptable standards. So assuming you can locate a harvest site that is suitable, you then have to build a facility which makes consideration of siting, power, labour pool and potable water supply. There would be difficulties in finding some of these in the wilds of Kyuquot as opposed to slightly closer to civilization.

What are acceptable limits in terms of the water quality that you are going to draw to your plant? Salinity should be approximately plus or minus 20% of the salinity of the harvest site. What you don't want to do is take shellfish from your harvest site, subject it to significantly different salinity, and have it shut down in terms of its pumping.

Turbidity - the water should be relatively clear. You can filter but you wouldn't want the water so turbid that the effectiveness of UV treatment is decreased. Turbid waters absorb the UV which decreases the effectiveness of the process to kill all bacteria.

Temperature - these animals are poikilothermic. Their metabolic rate varies with temperature so you don't want it so cold or hot that they shut down their pumping. If the water temperature is too cold in the winter time and you still want to depurate, you may have to look at heating the water.

Dissolved oxygen - don't put them into a situation where they are not getting sufficient oxygen for physiological activity.

pH - should be, and I think these standards are something that are being looked at, somewhere in the vicinity of 7-8.4 and no chemical pollutants.

DEPURATION FACILITY

The first thing needed is some sort of pump system to bring in the water with various water cleaning devices built into the system, a strainer for extremely coarse material (although I don't know why you would site in an area where you would need a strainer), a filter to take out some of the finer material and a flow control system. If you're supposed to depurate within 48 hours the water flow must be continual. The water is passed through a UV sterilizer and then delivered to the various depuration tanks and then out through a waste drain. We are not really looking at high tech here, that is not to say that it doesn't cost money, but there is no real secret to these systems.

The product comes in and it is put into a washer where culls and dead product are taken out. If you put dead or damaged product into depuration tanks it will contribute to contamination. Fill your baskets with the product and weigh them because the flow rates are determined by

weight of the product in the tanks. The product filled baskets are placed into the tanks, where after 24 hours, the product is removed for washing to remove faeces, pseudo-faeces, etc. After 48 hours they are removed from the tanks, washed again and then placed into whatever type of clean packaging is being used, whether it is boxes or sacks, and then placed into cold storage. People who are in the business of processing clams right now will see that most of these steps already occur simply in handling so you are not necessarily adding a lot of steps. There are a couple that I will get into and these are ones that D.F.O. requires. In terms of system design and layout you require separate holding rooms. You can't mix product that comes from contaminated areas with depurated product.

We don't have any approved sort of basic design. In other words, you can't go to the shelf and say okay here is a book of plans and if you want to build a certain size of facility to do so much product then I am going to take design four here and I know if I build it according to those specifications, I am not going to have any problems with it meeting inspection standards and I know roughly how much it is going to cost. What exists are guidelines, and guidelines are open to interpretation and therefore each individual operation can be looking, to some degree at different requirements. I think if we are going to go the way of depuration as a large scale activity in the province such as occurs in Europe, we need a better focus on what is acceptable in terms of physical plants and operations. I was just talking to a gentleman who was recently in Spain and there they have thirty facilities and everything is depurated regardless of whether it is clean or not. But I am not promoting that here. I am simply saying that if we go towards depuration, it might be handy to have some of these standards a little bit better defined.

But I digress, in terms of general specifications, we must examine hydraulic flow. There must be a minimum amount of treated water going through the tanks and the standards that are currently in use are approximately 0.5 to 1 gallon per minute for each 50 pounds of clams. There should be no dead spots in the tanks and each clam is supposed to have equal exposure to the treated water. If you have dead spots, they are not going to depurate as fast. The materials need to be easily cleaned. The basic tank design that has been developed through work on the east coast and at Ladysmith in the early 70's seems to indicate a rectangular 4 to 1 length to width design will provide this hydraulic flow requirement. There should be a minimum of 8 cubic feet of water for each 50 pounds of clams. There is a minimum volume required plus a flow through requirement of approximately 10-20 gallons per thousand pounds per hour.

The baskets should be about 3 inches deep maximum because we are dealing with a short siphon type of clam with Manilas and they need to be able to get their siphons out to the water. If you pile them too deep, the clams in the middle wouldn't be able to reach into the clean water, thus increasing their depuration time.

An in-line flow meter is required to guarantee minimum flows are maintained. A solenoid shut off is also required so that if the UV system fails, it automatically shuts down.

Shell stock has to be kept cool prior to processing because fecal coliforms can multiply inside the clams. You may start out with product that meets standards but if you throw a couple of sacks of clams in the trunk and leave it parked on the beach in the middle of summer, your count is going to be a lot higher after a couple of hours.

There is going to be sampling required over and above what is required to determine if your site is suitable to harvest. Pre-depuration samples are required and those can't exceed 2300 fecal coliforms per 100 grams meat content. There are post depuration samples required to insure that, in fact, the depuration facility is working properly. There is intent built into the guidelines that once a system is up and operating properly, and there is some confidence that it will continue to operate to standards, then the sampling regime can be backed off. So in a nutshell, that is what we are looking at for cleansing product and an overview of what considerations go into controlled depuration. That is all very nice, but what the hell is it going to cost me?

I would like to be able to sit up here and say it is going to cost you 5, 10, or even 20 cents a pound but I don't really think anybody knows exactly what it is going to cost for any one type of system to process clams from a controlled depuration standpoint. There is only one facility that is currently in the process of getting approved. There is another one that is close to getting approval. So really we don't have plants that are up and operating. Looking at some of the east coast literature, 5-10 cents a pound was the cost they assessed for soft shell clams in the 70's. How does that relate to today? Are the systems more efficient? Can you push more product through? Obviously these can be related to whether you have a larger facility, whether that facility is operating up to its maximum and how effective the management is.

Operational costs are going to vary to some degree with the size of the plant, capital costs, how you carry those capital costs and how long you carry the capital costs. We really can't say what it is going to cost but I think to some degree that if you put a product through, whether it is a purging system or a controlled depuration, I think you are going to be able to market your product as something a little more than just beach run. You then should be able to demand a higher price for that product. How this will relate to your costs I can't answer but I certainly think that those clams should command a higher price on the market. I again would like to see some sort of standardization of the design so people have a much better feel for what they are actually getting into before they are into it. Costs relative to capital should certainly be part of that and I would like to see some up to date figures on operating/capital costs that are scaled to various size facilities so if someone wants to do 1000 pounds a week and someone wants to do 10,000 pounds a week, they can go to an information source to say okay within these parameters and these guidelines, it is going to cost me this much to build it and this much to run.

Something else that needs to be looked at, as the information appears to be contradictory, is what effect tank holding has on product shelf life. I would like to see some more definitive work done on that, and not just only with Manilas. If that work has been done and anybody is aware of

it, then I would like to be made aware of it. Another thing that should be investigated is product quality after freezing. Not necessarily like in the old days when 50,000 pounds of clams arrived on the doorstep at 3 a.m. and you could only process half of that. The rest of the sacks got chucked into the freezer. That is not the type of freezing that I am considering. We should look at blast or Individual Quick Frozen (I.Q.F.) to prepare a product that is going to be acceptable to the market. I get some feeling that there is some potential for this so we can then have a product that goes from a fresh state, through purging or depuration, and then right into freezing. It gives that ability to market out over a longer time.

Question : You have people who are not responsible digging places where the beaches are closed. How do you control that?

That is an enforcement problem and there are attempts by the British Columbia Intertidal Clam Processor Association, in consultation with D.F.O. to deal with it.

Question : Is depuration necessary for shellfish that are contaminated?

Well, you wouldn't be allowed to harvest from areas that exceed the standards. If it were shown that the areas were contaminated with fecal coliforms, you would not be permitted to move from those areas without a special permit from D.F.O.

Question : Can you provide us with some of these regulations?

When you get your proceedings, you will get the complete attachment of the D.F.O. guidelines, and those sorts of details are explained in there, in terms of what the applicant is required to do for on-site testing prior to permitting.

Editor's Note : The Fisheries Inspection Guideline is provided in Appendix V.

MARKETING CLAM PRODUCTS

Mr. Ray Leitch, Albion Fisheries Ltd.

In the area of marketing I would like to cover the following areas:

1) growth of the market;

2) littleneck versus Manila;

3) handling and quality; and

4) new markets.

1. GROWTH IN THE MARKET

I have prepared several graphs showing the harvest of Manila and littleneck clams, the dollar value and monthly harvest.

A) Manila and Littleneck Clam Harvest 1982 to 1988

The first thing that sticks out is that littleneck clam harvest has remained relatively stable in the past six years (Figure 16).

The Manila clam harvest in 1982 was 596,854 kg and it has escalated to over 3,600,000 kg in 1987. It is estimated that the 1988 landings will be less than the 1987 landings at an estimated total of 3,250,000 kg. The total growth in landings from 1982 to 1987 is over 445% (Table 6).

B) Dollar Value - Manila and Littleneck Clams

Figure 17 lays out the value paid to harvesters for their clams from 1982 to 1988. Please note that the 1988 value is based on only 9.5 months. The value paid for Manila clams has risen from $1.023 per kg ($0.464 per pound) to a value of $1.942 per kg ($0.881 per pound). The total dollar value in 1982 was $611,121 and the estimated value for 1988 is approximately $6,323,723.

2. LITTLENECK VERSUS MANILA

The Manila clam is preferred by all end users for two specific reasons :

1) shelf life is 10 - 14 days for the Manila clam and only 5-7 days for the littleneck clam; and

2) Manila clams open easier when the have been steamed. Most littleneck clams are frozen in the shell and do not open as easily as the fresh product when steamed.

3. HANDLING AND QUALITY

There has not been a large change over the past few years in the handling of the clam product from harvest to retail marketing (Figure 18).

I feel that both the industry, government and educational systems must work together to come up with the best way to handle fresh and frozen product to assure the consumer is receiving the best quality product possibly available.

As in the past the wholesaler and retailer are concerned with the freshness of the product. Can we be assured that the clams we are buying were actually dug on the same day as stated, was the product properly held in coolers, has the product been washed and graded to minimum sizes and has the product been properly purged?

In the years to come I can see the end user demanding that the product be purged and/or depurated to ensure the highest quality product.

If the product has been frozen, has it been frozen at it's peakness for high quality?

4. NEW MARKETS

As the transportation system improves, the distance from plant to market increases. Probably back in 1982 the market was in, and around, British Columbia. In 1988 the market is far and wide. The west coast of the U.S.A. was the next area to accept Manila clams from B.C. and as air and truck transportation improved, the market has expanded across Canada and the U.S.A. In the past few years we have even started exporting to European and Asian countries.

The market is continuing to grow at a rapid rate and UNLESS we start culturing clams, we can foresee a large shortage of product as illustrated in Figure 19.

To assist in the market growth we must look at, and determine, better packaging, handling, quality freezing and value added products (Figure 20).

Figure 16: Landed quantity of Manila and littleneck clams from 1982 to 1988.

YEAR	KG	LBS	$	PER KG	PER LB
1982	596,854	1,315,765	611,121	1.023	.464
		75.79%	70.7%		
1983	1,049,236	2,313,041	1,043,419	.993	.450
		48.30%	73.8%		
1984	1,677,324	3,430,127	1,813,024	1.08	.500
		22.98%	25.6%		
1985	1,913,511	4,218,335	2,277,600	1.19	.540
		(1.02%)	21.3%		
1986	1,893,955	4,175,224	2,761,940	1.458	.713
		90.48%	32.4%		
1987	3,607,565	7,952,877	6,002,833	1.664	.755
		(9.72%)	5.3%		89.87%
1988 *	2,631,294	5,800,688	5,109,422	1.942	.881
(EST)	3,256,294	7,179,878	6,323,723		
		445%			

* 9½ MONTHS

Table 6: Recap of Manila clam harvest from 1982 to 1988.

Figure 17: Dollar value for Manila and littleneck clams from 1982 to 1988.

PAST: Fresh - net sacks 40 - 100 lbs sold close to harvesting area.

Frozen - bulk and 2 lb bags usually froze product you could not sell fresh. Could be up to 10 days old.

PRESENT; Fresh - net sacks usually 25 and 50 lbs sacks. Some packing in 5 and 10 lb vexar bags.
With the much improved transportation both road and air product being shipped to Europe, East Coast Canada and U.S.A.

Packaging: Cartons, wet lock boxes, styrofoam boxes use of get packs.

Frozen - Not much change still majority is product frozen because of unable to sell.

FUTURE: Fresh - better packaging with the use of vexar, oxygen and styrofoam boxes.

Frozen - Unless we carry out research into how to freeze properly littleneck and manila clams cannot see market growing.

Value added - Again we should carry out research into how to process into value added products. Half shell product, stuffed clams.

Figure 18: Marketing practices: past, present and future.

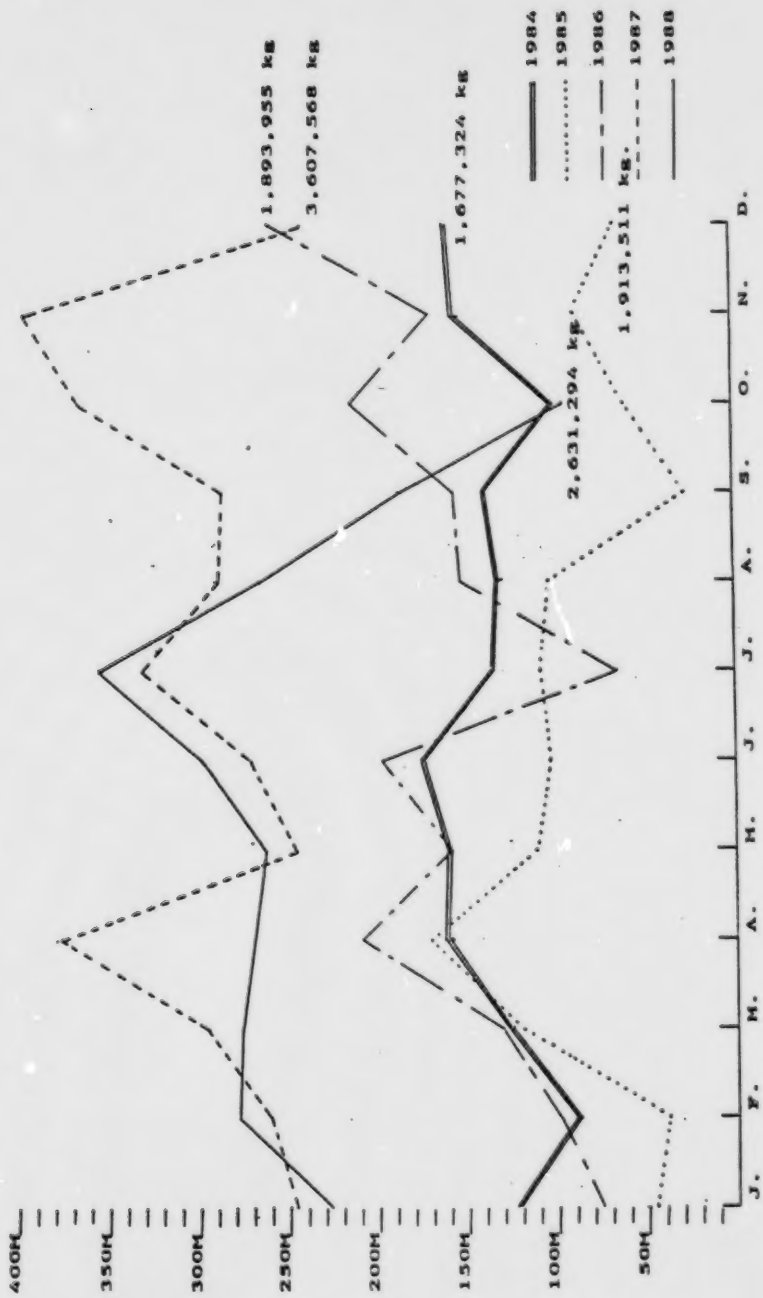


Figure 19: Monthly Manila clam harvest reported by Department of Fisheries and Oceans from 1984 to 1988.

1. Cleanliners - Major problem and should be corrected to give British Columbia a good name.

2. Sizing - The institutional market requires a sized product so they can present a uniform product to the public.

3. Tagging - Is a major problem and feel we should move to a tag issued by one government agent and insist it be on the outside of the bag.

4. Storage - From the digger to the end user we must educate how to to handle and store.

   Live Tank: up to 48 hours
   Cool Room: 37 - 39 ^{0}F, cover sacks with gunny sacks or material so that they do not get a chill, spray mist room or sprinkle water so that clams do not dehydrate.
   Shipping: Use of oxygen for long trips.

Figure 20: How to improve product to increase sales.

MARKETING CLAM PRODUCTS

Mr. Leigh Loader, Redonda Sea Farms Ltd.

My presentation will be quite similar to that of Mr. Ray Leitch. However, I am going to discuss fresh product which is the only product that is really being moved out now. In the future, possibly a frozen product will be sold that can create more jobs here and will solve some of our shelf life and consistency of supply problems.

On the fresh side there are basically two distinct clams marketed, the Manila and the littleneck. As Mr. Ray Leitch discussed, they have radically different shelf life and they also have different customer appeal. The littleneck for example doesn't steam as easily so it is more irregular. You might get 25% that don't open after steaming which translates to a loss to your end user. Basically the Manila clam market is well established and extremely well received. It is a versatile product if handled properly with an approximate 10 day to 2 week shelf life. It is well liked by southern European and Asian end users for it's sweet taste and ease in preparation. The market for Manila clams is very promising, although, based on current harvest statistics, we may have already peaked in our production. We have developed a market that, unless we get into some sort of enhancement, we are going to end up losing to people south of the border - those who are enhancing production.

With the littleneck clam, the meat is well liked but definite problems exist in the fresh market place due to the short shelf life and the shells do not open when steamed which presents problems for the end user. Possibilities could exist if the value of the product rises enough to warrant application of new technology to modified environment packing. This product is definitely not being utilized to its maximum potential right now as anyone that buys or sells clams knows. It is hard to market littleneck clams. I know at Redonda Sea Farms we have a hard time marketing them on any consistent basis.

In the frozen state both have a great potential in the market place. This is where the market place is going. At the Food Marketing Industry Conference this summer in Seattle, they projected that the seafood consumption in the States is now around 14 pounds per person. They are projecting that by the year 1992, it will be up in the range of 21 pounds per person.

Besides the problem of relatively short shelf life, 5 days for the littlenecks and 10 days for the Manilas, we are also going to have a problem with moving the fresh product to those market places. It is easy enough if we are thinking of Vancouver as the Big Apple, but we shouldn't. I mean not much of our product ends up in Vancouver. Washington we can fly the product there in a few hours. California is accessible by road. North America is accessible in 2-3 hours by air transport if you can get the available cargo space on the plane. Anyone that has tried to book planes and cargo spaces knows how precarious this can be.

Other products are worth more money. The $5.00 per pound pieces of salmon and the $10.00 smoked salmon can absorb a fifty, sixty or even seventy cent a pound cost added to their product. When you are dealing with a product worth $1.40 to $1.50 if you tack on 60 or 70 cents to the price it is not going to be attractive anymore. What the retailers will be looking for is to see what it is going to cost them and what they can sell it for.

Benefits of frozen product - there is no product loss due to shelf life and there are extra jobs in our local community as the secondary processing goes into the value of the product. This can be freezing, the glazing of the product afterwards, the special packaging that goes with smaller units and sauce preparations for precooked and microwaveable product.

Previously you could throw unsized clams into a bag and they would sell. Now the end users are becoming more picky and definite in what they want. Definite trends are showing up. As an example, southern Europeans and Italians like a small clam for steaming and using with linguine. The Asians have a preference for large shellfish, be it oysters, clams, or whatever.

The importance of sizing also applies to frozen product. Different size clams can be used for different things. Smaller clams can be used for vacuum pack frozen linguines or lean cuisine type of food (which is a very big seller in the market place in the States now) or with the bigger clams they can be shucked and the meat can be ground and marketed as a stuffed microwaveable product.

Consistency in terms of being able to supply a product of uniform quality on a regular basis is very important for growth in the market place. We are going to see problems now because we have developed markets and the number of customers is growing BUT our availability of product is decreasing. With these markets people are relying on us for supply and were not going to be have it so they are going to phone other people. Possibly the people that have a consistent supply through farming will take over the markets.

A steady year round supply is much more desirable than peaks and valleys in production. It serves nobody to have oversupplies in quantity at certain times. As one can imagine when there is an over harvest of any fresh product, supply and demand takes over as the market place is not geared to accept huge volumes at small notice. Prices invariably must drop or product is lost to spoilage. Product must be frozen to regroup some of these losses. Again your frozen product takes care of a few of these problems and can give you the consistency in supply. It also gives you the availability to stockpile during oversupply times and then sell consistently throughout the year.

Cleanliness of the product is very important. It is something we can't say enough about. Any problems with hygiene or sickness associated with a product that we are producing here could wipe us out. An example that readily comes to mind is what happened last spring in P.E.I. with their mussels. They still haven't recouped the market share that they once had, people are still wary of eating mussels.

One of our greatest marketing advantages is the perception of our clean, unpolluted environment. The preservation of this perception and reality must be maintained and enhanced if possible. The Department of Fisheries and Oceans diligence in checking contaminated product is very important in helping us maintain a clean image. That is one of the advantages we can sell once our product becomes more expensive than the competitors.

Storage and handling is also extremely important. Once the clam is removed from its natural habitat, the time clock starts ticking. Short of returning the clam back to the beach, it only has a certain maximum time window before it spoils and dies. Correct handling all the way will help maximize the storage time. A quick cooling of the product to a temperature between the 35-38 degree Fahrenheit range is important, especially in the summertime. Those clams are very hot by the time they come in at the end of the day. You have just sliced a few days off the shelf life. That's fine if your market is only Vancouver, you can get them in there and get rid of them in a day or two but if you are looking at markets in Europe or southern Asia, those 2-3 days that you lose here could be very important. If you have a product that you are shipping and you are paying a couple of bucks a pound to get it to the destination and it arrives dead, not only have you lost your product, you have lost a lot of money in freight and you have a disgruntled customer who will look for someone else who can handle their product properly. Every change in temperature adds further stress to the animals and hastens spoilage. This starts with the digger on the beach. Poor handling here is not always noticeable but when the product is delivered, it will start to show up in a few days further down the distribution chain. Some of the markets are now 3-4 days away even by air so you can imagine if you lose much product, you are not going to be in business very long.

Frozen product will help solve some of these problems and we can start sending product to Europe by boat very, very cheaply. We can get a consistent product if we do the freezing properly. If it is consistent we can market it on our terms instead of having to slip and slop every time an opening comes up and 200,000 pounds of clams suddenly land on the beaches in a few days.

I think that the industry here has worked pretty hard in changing to what the market needs, for example sizing of clams. Some end users like black Manilas compared to the multicolored Manilas and we are responding to that demand. Also the packaging is getting better and more uniform.

In the past, there was more product than the market could handle so there wasn't a need for grading littlenecks out from the Manilas. Sizing wasn't really a thing that was ever done and little money was spent on packaging. Basically your old onion sacks were used many times over and most of the markets were close by as opposed to being half way around the world. It seems that the market is overtaking supply now and the range of the market is expanding. We now market to the U.S. east coast, Europe and Asia and there is a definite product short fall coming which will hinder growth in the long term. Aquaculture seems to pop right in there and if we start now, in 3-4 years when those crops start to come on we won't totally be forgotten in the market place by the time

we start to harvest cultured clams.

Another thing we have to look at is the value of our Canadian dollar. We can only increase our prices so much before the competitors just south of the border, whose dollar value is not changing, are going to have a definite advantage. If you are culturing a product you have a little more control on what your product is costing you to bring into your plant and process.

This all I have to present. We touched on a few of the major issues like consistency and quality which are paramount to us being a successful industry. If we don't have the product on the beaches then it just seems natural that we should try and culture some ourselves before we loose any gains we have made in the marketing of the clam product.

PROVINCIAL AID AND STRATEGY IN MARKETING

Mr. Don Rugg, Ministry of Agriculture & Fisheries

I was requested to speak today on the strategies and aims of the Marketing Branch within our Ministry and as well give some insight from my experience in how to obtain the export market. Now from what you've heard from Mr. Ray Leitch and Mr. Leigh Loader, obtaining the market is not that difficult. Keeping it may be and I certainly concur with the positions that they were taking with regard to quality, quality, quality!

The B.C. Ministry of Agriculture and Fisheries, for those of you who don't know, has a number of divisions. The Aquaculture and Commercial Fisheries Branch falls under our Assistant Deputy Minister of Financial Programs and Aquaculture and Commercial Fisheries. The Marketing Branch report through a slightly different route. We are tied in with Trade Analysis, Marketing and Regulated Marketing. The responsibility for marketing board legislations and various types of grading acts fall under our division.

Figure 21 shows an outline of the Marketing Branch. The groups that we have are not large. Under me I have the Dairy Lab and Brands Program which are there because they couldn't figure out where else to put them. We also have a Commodity Group (which is composed of three individuals), a Programs Group and our Food Processing Sector.

The goal of the Marketing Branch is to stimulate the growth and development of the B.C. food industry by increasing marketing expertise, increasing export markets and encouraging import displacement in the food service and retail sectors (Figure 22). From the perspective of the aquaculture industry, and particularly the clam sector, the Commodity Officer who has been designated to interface with this group is Mr. Duff McCaghey.

Mr. Duff McCaghey has very recently joined us. He was working with export marketing and so has been dealing with some of the seafood areas in the province for the last year or year and a half.

The next sector that we have is Food Processing composed of Mr. Al Halmersen, our food processing specialist. His role is to assist companies in the areas of product or package development and food processing technology. Generally access to Mr. Al Halmersen would come through the Commodity Officer though this is not mandatory. Both gentlemen are located in our Victoria office.

The final group that we have is our Market Access Group. This is our Market Development Specialist, our Retail Specialist and our Food Service Specialist. Their role is to work directly with the retailers, the food service area and the ultimate consumers to determine what are the requirements to promote B.C. products into the sector and bring back the information to the Commodity Group or the Food Processors as to what is required and the problems that are existing. For a lot of you that have been in the market place, you will recognize that sometimes you

lose a market and you never know why. You simply never get calls from them anymore. What we attempt to do is find out why and attempt to rectify the situation. If it is a problem with quality, we will come back and talk to you about what you need to do in order to keep that market. We provide a liaison operation. Though this group has been in place for some 13 years, it got to the point that it was down to nil about two years ago. Just within the last six months, we staffed back up to three people.

This details the types of activities that we carry out. We also host seminars. There are a couple coming up that I thought I would let you know about. Very recently we have become aware of the cruise industry in British Columbia. The provisioners for the cruise ships out of Vancouver have an organization and we are working with them in putting on a seminar on February 1st which will be aimed at telling processors and suppliers how to access the cruise ship industry out of Vancouver. There may be opportunities for processors there. The other seminar which will be later that month, February 23rd, will be held at the Richmond Inn and will be aimed at showing small producers and processors how to access the retail market. It will be entitled "How to Sell to Retail".

Figure 23 details the programs that we administer. First of all we have our Food Industry Development Program. This is a Financial Assistance Program co-chaired by myself and Mr. Al Sakalavskas.

The objective of the program is to encourage growth and diversification in the B.C. food processing sector. Proposals will be considered for financial assistance if they provide significant economic benefit to the province, development of new or expanded markets, introduction of improvements in food processing technology or the development of new food products. Financial assistance is offered in the form of a grant and normally doesn't exceed 50% of the costs or a maximum of $50,000.

There are four categories that we deal in: new food product packaging development; market research which is one that we promote fairly heavily; new processing technology development which is used somewhat less; and productivity advisory services which hasn't been used very much at all but which we feel will probably increase in the years to come.

The program is aimed at the food processing sector but we take a fairly broad view of what food processing is. We have had one program in the last eighteen months with somebody within the industry looking at the market potentials of littleneck clams.

The next program that we have is our Food Product of British Columbia Logo Program (Figure 24). For those of you with long memories, you will recognize the "home grown B.C. quality" logo which has been around for quite a number of years. This was developed as a domestic identification program for B.C. products and one of the things that we discovered years ago was that B.C. consumers are willing to pay a premium price for B.C. products if they are of equal quality. That was one of the reasons why we developed the program.

The logo was developed for export markets because a number of processors said "we want to put some sign on our packaging going into export markets that says we are from British Columbia". Our Premier picked up on that and we developed this logo. Now we have some 80 companies that have applied to use this logo on their packaging and we will probably see increased use of it, both in export and in Canada.

The next program that we have is the Export Assistance B.C., B.C. Trade Representatives, B.C. Business Information Center and the New Exporter to Border States Program are all administered through the Ministry of International Business and Immigration (M.I.B.I.). Up until very recently we had an export market marketing program within our Ministry. That program has now been moved over to M.I.B.I. who will be setting up a Crown corporation, a B.C. Trade Development Corporation, which will be administering these programs. We do however anticipate that those programs will continue.

The four programs composing Export Assistance B.C. are the Trade Mission Program, Market Development Program, Incoming Buyers Program and Trade Show Program. The Incoming Buyers Program is very useful if you've got overseas buyers and wish to bring them in to see your production facilities and B.C. itself. As both Mr. Ray Leitch and Mr. Leigh Loader alluded to earlier, once you get them here, British Columbia pretty well sells the product for you. The type of climate and the relatively uninhabited area in which we live compared to most of the rest of the world really does help sell your product.

The Trade Show Program assists you in taking part in trade shows. A number of people that I have talked to here have taken advantage of this program over the years. It is one that we will be working very closely with M.I.B.I. on as we are the industry contacts and they have the export development contacts. We will be working with them in taking companies into trade shows outside of British Columbia. Shows that we know that some companies are going to be going into are the Boston show next spring and Seafair in 1989 in L.A.

The next program that they have are the Provincial Trade Representatives. There are offices established in London, Tokyo, Hong Kong, Dusseldorf and Seoul. In addition, new offices are just being set up in Singapore and there is one going to be set up in Los Angeles. These offices are to assist British Columbia processors in accessing those markets as well as to promote British Columbia as a sound investment location for monies from those areas.

The B.C. Information Center is located at the Enterprise Center in Vancouver on the old Expo grounds. If you ever get a chance to get over there, it is worth going into because they have the listings and people there to help you take a look at virtually all of the government programs available. One of the problems with so many departments and so many people involved in programs is that it is difficult to know what is going on at any given time and they at least attempt to keep up to date on what is happening.

Finally the New Export to Border States Program (N.E.B.S.). It was launched in 1985 to assist small and medium size businesses who have not

previously exported but are interested in markets in the U.S. border states and which have been identified as export ready. This is operated in collaboration with the provincial governments and the regional offices of the Department of Regional Industrial Expansion and gives small businesses a crash course in the essentials of exporting. Participants are taken to the nearest Canadian Trade Office across the U.S. border, in our case it is usually Seattle, and over a one or two day period, are ushered through all phases of exporting from customs clearing procedures to warehousing and distribution of goods. They attend briefings from experts from both the U.S. and Canada such as manufacturer's representatives, freight forwarders, customs brokers, bankers and others familiar with the ins and outs of selling Canadian goods and services in the U.S. Participants also have personal interviews with the Trade Commissioner from the Canadian Trade Office who can help them develop a marketing strategy to meet their particular needs. The visit to the Consulate is an excellent opportunity to use a post network of contacts to arrange follow up meetings with the manufacturer's representatives and potential buyers.

As well as all of these programs, there are a number of federal programs. We have a kit available today and while we don't have enough for everybody, for those interested please contact us in Victoria. These programs include "So You Want to Export, Making the Initial Decision" which is a booklet that is put out by the federal government and is very complete and worthwhile for anybody that is entering into the export market. There is also a listing of Canadian Trade Representatives abroad in virtually all countries of the world with which we trade. The Export Market Development is a program which once again a number of people here have used. It basically will pay airfares for you to enter into new markets. It will also help bring in incoming buyers and assist you in getting into trade shows, very similar to the type of program that we have with M.I.B.I. The only thing we don't allow is stacking of programs, you can go to the federal or provincial government. The level of support is usually about the same.

The last is one I hadn't heard about until I read the notes that Mr. Duff McCaghey had developed for this talk. It is called the World Market Development Program and it is a new federal program announced September 29th. There are not a lot of specifics but we can tell you that the government intends to allocate an additional $57,000,000 to new trade promotion activities over the next five years. Specific elements of the program deal with the U.S., Asia, Pacific and western Europe.

The final thing that I was asked to talk about was obtaining the export market, which has been covered very well by both Mr. Ray Leitch and Mr. Leigh Loader. I just wanted to reiterate a couple of things.

I think it is valuable to use the programs that we have. The Food Industry Development Program (F.I.D.P.) enjoys getting good market research projects. We like to see good market research because to a large extent most companies haven't done very much of it over the years.

I believe that growers should grow and marketers should market. So one of the first things I think a good grower needs to do is line himself up with a good marketer because you are different personalities to start

with and a top notch grower very, very seldom makes a great marketer.

You need to key in on a specific area and develop it. Don't try to be all things to all people. Join with other producers to get some critical mass. I like the idea of freezing and being able to enter into markets so that you can spread out over longer periods of time. I think the one area that we are going to have a little bit of difficulty in is getting around the mystique of fresh. I'll be honest I've never used fresh clams, I thought they always came frozen.

Use the B.C. and Canadian foreign offices. Bring in buyers to see British Columbia. Check the regulations going into export markets. That is one of the places the New Exporter to Border States Program (N.E.B.S.) is useful. It runs through the type of regulations that you are going to have to deal with in crossing the borders.

Package for the market. We are going to need to do a lot of work in the packaging area in this province, not just for clams but virtually all of the products we are marketing. You need to produce the product that the market desires.

When Mr. Leigh Loader suggested that some may want little black clams, somebody at the back said "well we got some dye". I don't think that is what they were talking about. What they want is a particular type of product and if we are going to be effective marketers, that is what we need to give them. We need to give them what they want, not just what comes off the beach or out of the ground.

The example I like to use is potatoes. Dealing in agriculture and fisheries, we cover everything. If you go into a retail store and you want to buy a bag of potatoes, the one you buy for the most part is clean, relatively uncut and all the potatoes are the same size. Now do you ever go into the store and buy the ones that are dirty, that have great big ones and little ones in the same bag and that have all these marks on them because, as the producers say, you have to get them out of the ground somehow? Potatoes are no different than your product. Quality is first and foremost in the eyes of the buyer. If you can get past that, then we will work on taste. If they taste terrible, you won't get any repeat sales but if they don't look good, you won't even get that first sale.

The first sale is on the basis of what they look like. People like products that are all the same size and all the same color. That is not to say that you cannot sell everything that comes off your lease but you need to sort it, grade it, and you need to then identify the markets that those different products are going to fit into.

I think if you go home with that one message, it is the most important thing that I can bring to you today.

Question : Will the provincial government be developing a promotional program similar to that supported by the Alberta government with in store demos and major product specific promotional campaigns?

Is the provincial government going to do the same sort of thing? In other words, is Mr. Duff McCaghey as a Seafood Marketing Officer going to develop those programs and go into the stores. Probably not. The type of thing that we will be doing is the generic advertising such as "Buy B.C." and making those logos available to you as a marketer to put on to your packaging so that your detail people can get them up in the stores. Now the one thing that I will say is that the F.I.D.P. supports some promotional activities where we assist individual companies or associations. We really like to work with associations because we are getting a broader section of the industry. We normally assist to about 50% of the cost of doing point of sale materials and good quality brochures. One of the things that we use the F.I.D.P. program for is to beat people over the head that they have to put out top quality brochures. You don't put out a brochure on a 8 1/2 by 14 inch piece of paper on a xerox. You have to have colour and it has to be shiny. You have got to make people think that your product is the best product out there and then you have to deliver. F.I.D.P. can be useful for that. Albion Fisheries could come to us for a program to promote B.C. clams in stores. We would prefer to see a B.C. Clam Association come to us and say "We have $50,000 that we want to put into marketing B.C. clams, what we need to do is develop good brochures and good point of sale materials plus brand names and product quality". We did a project like this with the B.C. Salmon Farmers. For those of you who know the salmon industry, you know that the salmon farmers put out a quality control manual including some very good pictures on what constitutes quality in farmed salmon. We helped with that because that was one of the areas that we felt was necessary. If we do nothing else but increase the quality of the product being offered by British Columbia, we have done our job.

Question : Would you assist with the initial costs of designing brochures?

Yes, basically what we help pay for is the upfront designing and the development of the plates. We don't pay the ongoing costs of putting 10,000 brochures out every 3-4 months but it is a start.

Question : Do the projects have to be large or can they be smaller than the $100,000 range?

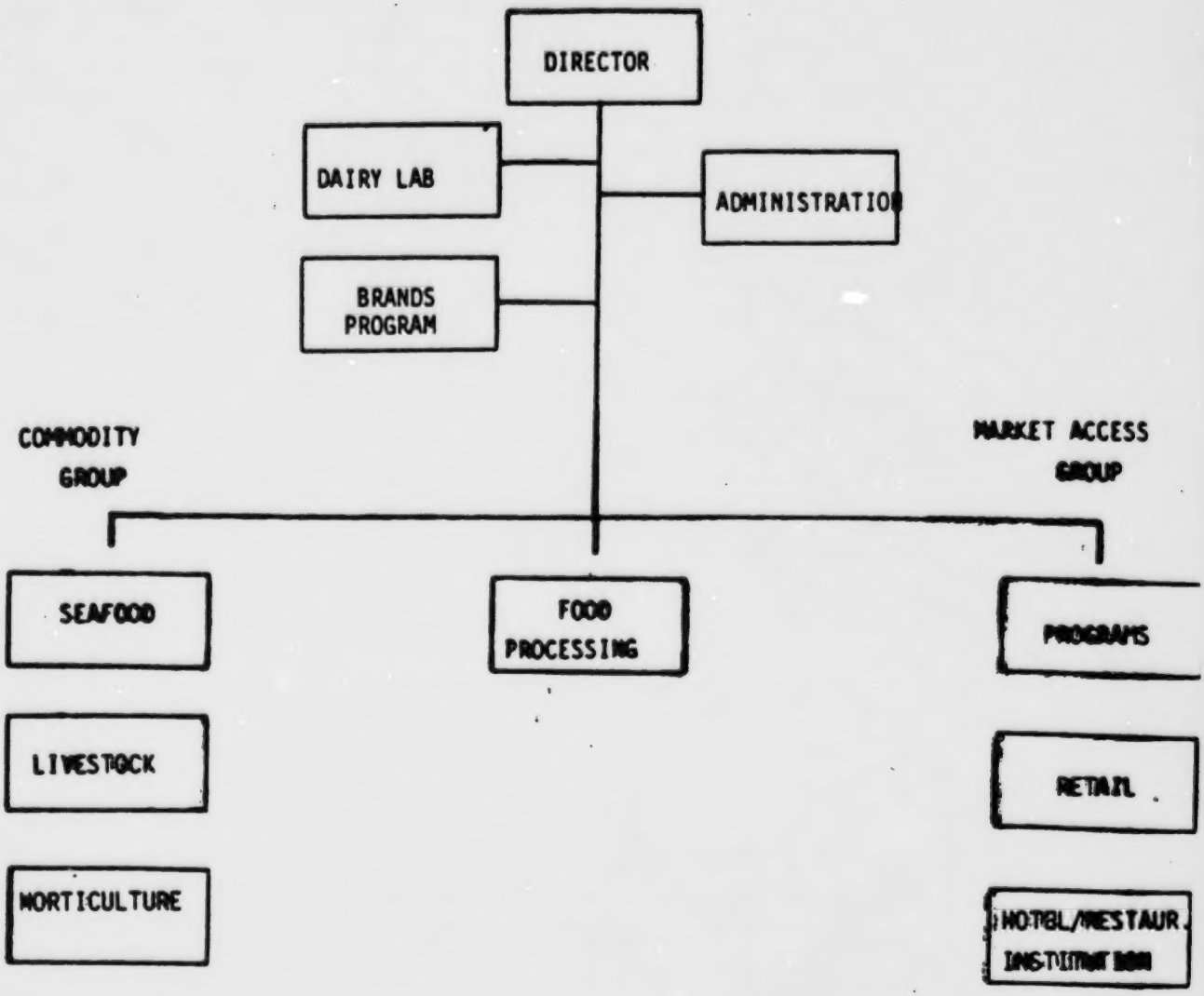
Well, it all depends on how you target it. Most of our projects are in the $10,000 - $30,000 total cost. We share up to 50%, depending on how much value we see for British Columbia.

Question : We know there are beautiful brochures on P.E.I. mussels coming out of eastern Canada fully supported by the government. Why can't we have the same thing here?

In the maritimes, monies come from the federal government. We have a real problem in that for our program, our marketing program here in the province, you people pay for with your taxes here in British Columbia. In the maritimes 80-90% of the provincial marketing programs comes out of federal money. The provincial tax payers are only picking up 10-20% of the program so they have more people doing marketing on Prince Edward Island than we have here in British Columbia.

Question : How much money do you really need to get these markets?

Let's start with $1,000. How far can you go? Seattle. We can put my $1,000 with your $1,000 and we will go to Seattle and have enough brochures to be able to hit the retail and the food service market in Seattle. Put $2,000 in and we'll go to San Francisco.



FUNCTION

- key sector contact
- industry liaison
- sector market extension
- market analysis
- market strategy development

FUNCTION

- food processing extension
- product/package development

FUNCTION

- generic program development
- product promotion
- market feedback

Figure 21: Outline of the Marketing Branch.

GOAL

To stimulate the growth and development of B.C. Food Industry by increasing marketing expertise; increasing export markets and encouraging import displacement in the foodservice and retail sectors.

Figure 22: Goal of the Marketing Branch.

PROVINCIAL PROGRAMS AND SERVICES

* The Food Industry Development Program
* The Food Product of B.C. Program
* Export Assistance B.C.
* B.C. Trade Representatives
* The B.C. Business Information Center
* New Exporter To Border States

Figure 23: Programs administrated by the Marketing Branch.

Figure 24: British Columbia food logo of the Marketing Branch.

Question : What are your thoughts in connection with the initiative created by the provincial government with the clam recreational only digging areas. What do you think that will do?

Mr. Norm Gibbons : I don't know very much about that but it seems to me that at some point we are going to have to come to grips with the issue that there are multiple users of this resource. It seems the way things are going that maybe certain beaches are going to have to be dedicated to recreation. I think that we all have to do is acknowledge that it is an issue and one that we have to face pretty soon.

Question : In the Nanaimo area, there was one area that for years was thought to be for recreational use only. Nobody has addressed the issue of just recreational beaches. What are your thoughts on this issue?

Mr. Norm Gibbons : I guess one of the perceptions of the public is that there are no clam to dig out there. I think that we have to clear up that perception and address whether or not the commercial clam industry and the recreational industry can exist side by side. That is the real issue. We have a similar situation on Savary Island. The reason why Savary Island is closed down from May until October really is because of the recreational harvest and there is no way that the recreational harvesters take any appreciable quantities off of that beach in that five month period because when it opens up in October, you can go out there and dig 100,000 pounds. I guess the issue is whether these things have to be separate or whether they can coexist.

One of the points I wanted to make is that I think with the way things are developing, we are conceptualizing clam culture and we are conceptualizing management of the industry. We are going down two separate paths and we are not able to see any way of integrating those two things. If we think about what clam culture is going to be in the future, it is not going to be the stereotype of clam seed being purchased, going into a nursery system, being grown out and being marketed as a total separate thing. I don't think in reality that is what is going to happen. That is not what is happening in Washington State and that is not what is happening anywhere else in the world but the policies and the regulations have put these two issues in separate places. There is no integration whatsoever. I think what we are ultimately talking about when we try to define clam culture is the enhancement of the wild fishery. I think that is the conceptual leap that we have to make right now and if we can't make that conceptual leap right now then I just don't see where we are going to go. I think that we are just going to get ourselves boxed off into corners. People are going to local levels of government to try to protect the wild fishery but nobody is going to get anywhere.

Question : Who legally owns the clams on the beaches? And how do we go

about protecting any future clam seed we may plant on our leases?

Ms. Frances Dickson : The wild clams on all beaches are a common property resource managed by the Department of Fisheries and Oceans (D.F.O.). Clam seed on a clam culture lease belongs to the lease holder. A commercial fishery would not be conducted on a clam lease.

Question : Since I have exclusive use of that land, doesn't this also give me exclusive rights to all molluscs?

Mr. Bob Cox : Well that is one where there is varying legal opinion and my understanding is that when those tenures were originally issued (and I am going to back pedal a bit on it, this was before I started working for the department) they stated this in effect for the culture and harvest of oysters and other molluscs but they did not basically have the legal right to state this because the other stocks on there were wild stocks and managed federally. That is why you don't see that on the documents anymore.

Question : Wouldn't there be a problem where you have wild clams and cultured clams on the same lease?

Mr. Bob Cox : Basically what we are saying, and Ms. Frances Dickson can correct me if I am wrong, is that where there is a suitable existing lease, and the lease holder wishes to revise the plan to include clam culture as part of the use on that tenure, we would have to consider them all cultured clams because there is no way you could separate wild from cultured clams. This isn't going to necessarily solve your problems because if someone comes on to your lease, are you going to phone Fisheries? Fisheries is going to say sorry, those are no longer a common property resource, they are private so therefore they do not fall under our jurisdiction. So it is a bit of a double edge sword.

Question : Can't I mark clam seed to differentiate it from wild seed?

Mr. Bob Cox : What I am saying is that you don't have to go to that extent on an existing lease. What will be created is private property rights, where some of the clams on the tenure will be recruited from the wild populations. I have also said that you can't differentiate between wild and cultured clams and it is probably impractical to mark them because once a clam digger has dug it, that is the only time he is going to know which is wild and which has been planted. The difference is between private property and common property resource. When you are culturing a product, it is no longer a common property resource. You own those clams, those oysters, those mussels, those salmon whatever you are growing. But because of that, you then may lose some protection under the Fisheries Act program that we tried to develop between the Ministry of Agriculture and Fisheries (M.A.F.) and D.F.O whereby unauthorized digging on your lease resulted in people being charged under Section 21 of the Fisheries Act. This would no longer apply because there is no longer a wild resource on that lease. It is a cultured product. So you see where I am drawing a distinction between ownership of that resource and because of the difference in ownership, there would be a difference in responsibility.

Question : Can't clam harvest be better regulated to prevent these problems?

Mr. Bob Cox : In the wild areas there are certain things that have to be brought in before you can start regulating such as specific licenses. Until those sorts of things are in place it will be very difficult to do but I would prefer that Ms. Frances Dickson or someone from Fisheries answer those questions. I don't want to put words in their mouths.

Question : Didn't a recent court decision give ownership of the sea bottom in certain areas to the Province?

Mr. Bob Cox : Yes, but there are a number of lawyers who are making a living discussing what specifically that decision meant in terms of ownership of related resources and I am not about to give a legal opinion on that. There is a difference between on the bottom and what is in the bottom. Those questions were never answered by that decision.

Question : It seems the policy on clam farming is being made by governments without input from the industry.

Mr. Norm Gibbons : I have identified the same problem as you. The B.C. Intertidal Clam Processors Association would like to be able to sit down with the people who make those decisions. I would also suggest that other people should be involved like diggers and their associations. I think diggers are going to have to get organized. They obviously have to get organized.

Question : Shouldn't clam harvesters be consulted on development of clam fishing plans?

Ms. Frances Dickson : I guess there are a couple things I would like to say. First of all, the B.C. Intertidal Clam Processors Association is a member of the Commercial Intertidal Advisory Committee; your association does have a representative on the Advisory Committee.

Mr. Norm Gibbons : But we don't sit down with the group that makes decisions on opening and closings.

Ms. Frances Dickson : What we did this year was to develop a Clam Fishing Plan for 1989. The plan was sent out to the advisors prior to our last meeting and it was assumed that all the advisors would meet with their representative groups to discuss it. There is one Clam Harvesters Association represented on the Advisory Committee but unfortunately most clam diggers don't belong to any organization. If organizations are formed, then they are welcome to apply to join the Advisory Committee. The Department is working towards getting a clam license in place. It will be introduced in 1989. Once there is a clam license, we can start to address some of the effort problems and try to look at effort control. When we have a clam license we could do things such as area licensing for example. In the interim, we've recognized the problems associated with market supply by developing the Clam Management Plan. We tried to stagger the openings throughout the coast so that we won't have all the clams harvested at once. Our first experiment in

reducing fishing seasons was on Savary Island this year where we went to a three day a week fishery. Now it turns out we picked the wrong three days despite the fact that the Advisory Committee recommended the three days that we used. We never realized we had the wrong three days until today so that is something we could change for the future.

Mr. Norm Gibbons : We would still like to meet with the Department to review the Clam Fishing Plan.

Ms. Frances Dickson : Well, your organization was involved in developing the Fishing Plan. We are always open to have a separate meeting with the processors if requested.

Question : What is the Department doing to address problems associated with handling and transporting clams?

Ms. Frances Dickson : The Department recognizes that problem. Actually it was brought up at the last meeting of our Advisory Committee. What they asked the Inspection Branch to do was to put together guidelines that can be given out to all clam harvesters to emphasize the importance of handling the product and transporting it.

Mr. Ron LeBlanc : I want to clarify something that is confusing to me anyway. Ms. Frances Dickson and Mr. Bob Cox made comments this morning that it is basically wide open for us to do a proposal or a Management Plan for our farms or leases to culture clams. This is the first time I have heard about it. I understand Mr. Bob Cox that you are sitting on a committee, to meet with the feds. Now is your stand to back up what we want, polyculture? Would the province be ready to stand behind it? Do you stand behind polyculture? It wasn't done. Last summer it wasn't. I applied for leases and I was blocked. Has the policy changed now? If I want to grow clams on my lease or apply for a lease next to my other lease so I can watch over it and so on, is it going to be a major problem for me to culture clams and oysters on that? Basically from last summer, it wasn't. I just dropped it because I didn't have time to fight it.

Mr. Bob Cox : There are two questions you are asking there. Existing lease and new leases. On an existing lease, you could carry out polyculture but if you want new areas they cannot conflict with the existing wild clam fishery.

MANILA CLAM DISEASE CONCERNS

Dr. Susan Bower, Department of Fisheries & Oceans

Since the fall of 1985, we have been conducting surveys of symbionts, parasites, and diseases of Manila clams (Tapes philippinarum) and oysters in British Columbia. This work has been partially funded by the B.C. Ministry of Agriculture and Fisheries and it has been through the careful work of Mr. Gary Meyer, Ms. Johanne Laliberté, Mr. Derek Nishimura, and Ms. Janice Blackbourn that we have obtained informative results.

Since 1985, we have examined at least 40 Manila clams from each of 15 different localities in British Columbia (Figure 25). Four of these localities have been sampled twice with at least 8 months between consecutive samples. At none of these localities have we observed parasites or conditions that appear to be causing disease in the Manila clams. However, these clams were hosts for many interesting parasites though none appear to be harmful to the clams.

At the risk of being pedantic, I would like to discuss two of the parasites that we have observed in the Manila clams. The first is a trematode or flatworm. Only the larval stage called a metacercaria is found in the tissues of the clam (Figure 26). The metacercaria is the resting or encysted stage in the life cycle of this parasite (Figure 27). Further development of the parasite will not occur until the clam is eaten by the final host which is most likely a bird or possibly a fish. The parasite will mature to the adult stage in the gut of the final host and eggs that are produced will be voided with the faeces of the host. On entering water, the eggs will hatch and the tiny free swimming stage called a miracidium will seek out a suitable molluscan intermediate host which is likely to be one or more species of marine snails. In this host the parasite will undergo asexual multiplication in the stage called a redia. Eventually a free swimming stage called a cercaria is produced. This cercaria will then penetrate and encyst in the connective tissue next to the gut of a suitable second intermediate host which in this case is the Manila clam (Figure 28). There is no evidence that this parasite is harming the Manila clam host other than slight displacement of normal organ structures.

The specific identity of this trematode is still not known. The parasite was carefully removed from the cyst and stained (Figure 29). However, the features necessary for identification were not yet developed due to the immature state of this early life stage. Nevertheless, the presence of a spiny collar around the small anterior sucker indicates that this trematode belongs to the family Echinostomatidae.

Metacercariae have been found in about 6% of the Manila clams from 8 of the 15 localities that were sampled. The few infected clams rarely contain more than 3 metacercariae each. However, the few populations of native littleneck clams (Protothaca staminea) that have been examined usually have a higher prevalence and intensity of this parasite but also with no obvious associated pathology. These parasites are innocuous in

the market place due to their small size (they are invisible to the unaided eye), and because they are not infective for humans.

The other parasite I will discuss are pea crabs of the family Pinnotheridae which live in the mantle cavity of the clams. Although these crabs apparently cause little or no harm to their hosts, they are unacceptable in the market place. We have observed pea crabs in Manila clams from 10 of the 15 localities examined (Figure 30). In 7 of these localities less than 2 of the 40 Manila clams examined were infected. However, high prevalence (for example 40% of the Manila clams from Denman Island were infected) may occur on some beaches.

Since 1985, we have investigated 6 reports of unusually high clam mortalities in British Columbia (Figure 31). Three of these concerned Manila clams and the other three involved native littleneck clams. Of the three reports that involved Manila clams, the first occurred in late winter to early spring of 1985 and affected at least 6 beaches at the north end of the Strait of Georgia (Figure 32). Curiously, some adjacent beaches and those further south were apparently not affected. We only became aware of the problem after many of the clams had already died. Nevertheless, we found a few moribund clams and examined them as well as samples of healthy clams from affected beaches. No infectious disease agent was identified as causing the problem. Thus, we were forced to conclude that either 1) we arrived on the scene too late and the disease agent had already died out with the bulk of the clams, or 2) the mortalities were caused by some unknown environmental factors such as below freezing temperatures during low winter tides or severe winter storms.

The second Manila clam die-off occurred in January of 1986 in Kendrick Arm just off Tahsis Inlet. Again, we could find no disease in the moribund clams we examined. Eleven months later, Mr. Gary Meyer, who was working with me on the investigation, observed a short newspaper article in the Times-Colonist that reported a fine levied against a paper mill in Tahsis for dumping toxic chemicals at about the time of the clam die off (Figure 33). We have no evidence to link the clam mortalities with the chemicals that were dumped, however, we are suspicious. The third Manila clam die-off occurred in one relatively small area of Nanoose Bay. Again, we could find no associated disease agents and the cause of the mortalities remains a mystery.

The three remaining reports of die-offs all mainly involved native littleneck clams. In these clams we found parasites that we have not yet observed in Manila clams. The most notable, because of the heavy infection observed in a few clams, is a sporozoan that usually occurs adjacent to the intestine (Figures 34 and 35). Another parasitic protozoan we have observed in native littleneck clams (Figure 36) was first described in 1984 by Moraldo, Sparks and Reed (1984. J. Invert. Pathol. 43:207-217.) from the kidney of native littleneck clams in Sequim Bay, Washington where heavy infections with this parasite coincided with numerous clams exposed on the beach surface (kick-outs). The infections we saw were not as heavy as those described from Washington. Because we have not had the opportunity to examine apparently healthy populations of native littleneck clams, we have no standard of comparison that may indicate if either of these parasites

were causing the mortalities. However, with these three reports of native littleneck clam die-offs, it was noted that the clams were very abundant on the affected beaches suggesting that the mortalities were ultimately attributable to overpopulation pressures.

In summary, to date, we have not identified any disease agents in Manila clams in British Columbia. However, there have been a few incidences of unusually high mortalities for which we do not know the cause.

A major ongoing concern pertains to the potential of disease introduction and transfer with the importation and movement of bivalves including clam seed and brood stock. Random transplant of bivalves (as well as other animals) can be compared to the deadly activity of playing Russian roulette. We know there are many more diseases in bivalves that we have not yet encountered in British Columbia. In addition to the recognized diseases, there are probably many more diseases that have not yet been identified. The more bivalves that we import, the higher the risk of accidentally introducing a disease-causing organism. There are a few international prime examples of the disasters that can occur with unrestricted importations. The flat oyster (Ostrea edulis) industry in Europe has been virtually devastated by a protozoan parasite that apparently originated from bivalves that were imported for culture. Thus, every time live bivalves are imported into local waters for grow out we are taking a chance. The only way to avoid this risk is to become self sufficient.

If the shellfish culture industry cannot become established nor survive without the importation of larvae or seed from foreign sources then the risk can be somewhat reduced by obtaining the bivalves from reputable sources (such as sources with a known disease-free history which includes periodic thorough histological examination of brood stock). The risk can be negligible if only a few brood stock are imported into quarantine and never released into the environment. If the F1 progeny experience low mortalities and are found free of known diseases on microscopic examination, they may be released from quarantine and used for culture purposes. In addition, less risk will be involved if the source of desired bivalves is geographically close. For example, if it is absolutely necessary to import clams for culture and with possible sources being equally reputable, importing clams from Puget Sound would involve less risk than importing clams from California. To import clams from Asia would be preposterous and comparable to playing Russian roulette with a loaded gun. The naive opinion that "it will not happen to us" was also held by the French at one time. However, the French, as well as most of Europe, no longer has a viable flat oyster industry due to the accidental introduction of the protozoan parasite Bonamia ostria with the numerous indiscriminate importations of various bivalve species into France. Hopefully, we have learned from their bad experience. The approach of becoming self sufficient in bivalve seed requirements within British Columbia should be the priority for our shellfish industry.

Question : Are there any diseases in Manila clams in their native habitats or place of origin?

The Manila clam was accidentally introduced with the Pacific oyster (Crassostrea gigas) that were originally imported into British Columbia

from Japan. To my knowledge, there have not been any disease studies conducted in Japan on Manila clams. Since I am not able to read Japanese, I do not have access to most of the Japanese literature. However, I have talked with several scientists from Japan and they were not aware of any studies on the diseases of Manila clams. Possibly Manila clams are not of sufficient economic importance in Japan to warrant studies on their disease problems.

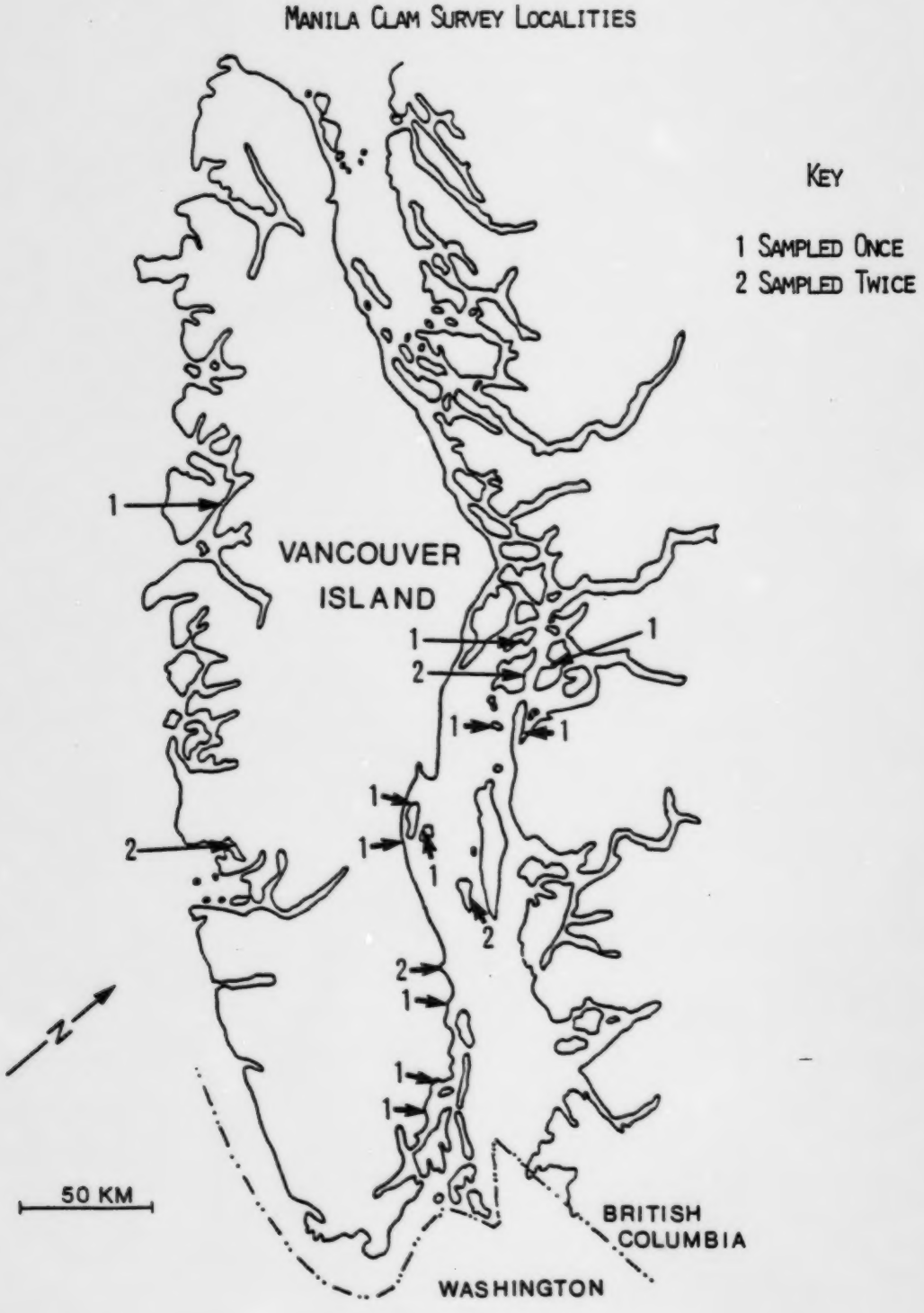


Figure 25: Map of Vancouver Island with 15 localities from which Manila clams (Tapes philippinarum) were sampled either once (1) or twice (2) indicated.

PLATE ONE

Figure 26: Wet mount presentation of a metacercaria (juvenile trematode about 0.25 mm in length) curled within a cyst that was dissected from a Manila clam (photographed through a microscope with a green filter over the light source).

Figure 28: Histological section through an encysted metacercaria in the connective tissue of a Manila clam (section was stained with haematoxylin and eosin and photographed through a microscope).

Figure 29: Stained whole mount preparation of a metacercaria removed from a cyst found in the connective tissue of a Manila clam. This metacercaria is about 0.25 mm in length and has a large ventral sucker located about mid-body and a small anterior sucker encircled by a spiny collar, which indicates that it belongs in the trematode family Echinostomatidae.

Figure 34: Histological section through numerous sporozoans within cysts that surround the gut of a native littleneck clam. Each cyst is about 0.05 mm in diameter (section was stained with haematoxylin and eosin and photographed through a microscope).

Figure 35: Same sporozoans as illustrated in Figure 34 except examined using higher magnification powers of the microscope. Each sporozoan within the cysts are elongate in longitudinal section and circular in cross section and are at a stage in the life cycle called merozoites.

Figure 36: Histological section through three macrogamonts and one resting spore of a coccidian (protozoan) parasite within the kidney of a native littleneck clam from Little Espinosa Inlet (section was stained with haematoxylin and eosin and photographed through a microscope).

Figure 26

Figure 28

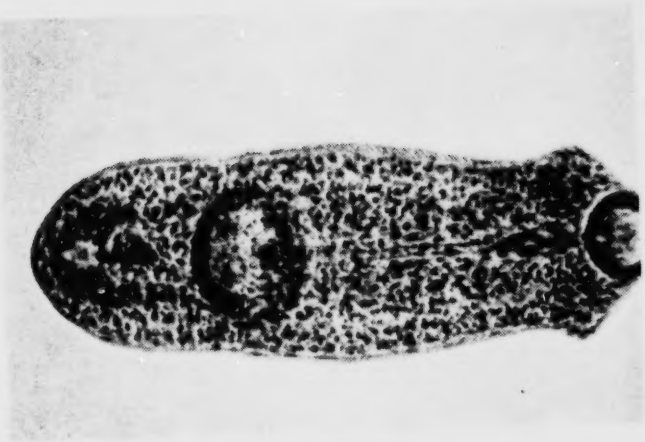


Figure 29

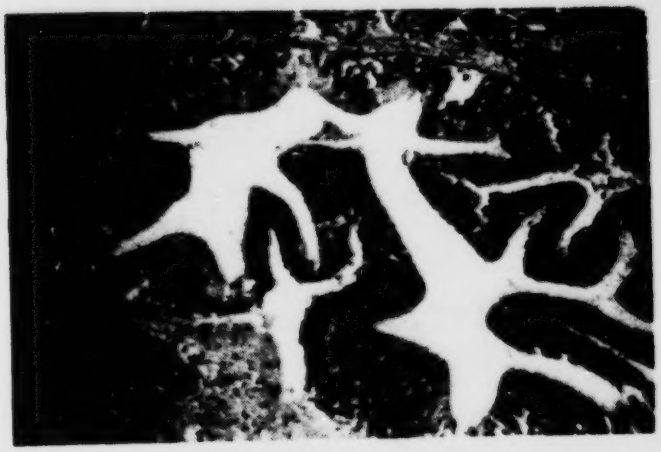


Figure 34

Figure 35

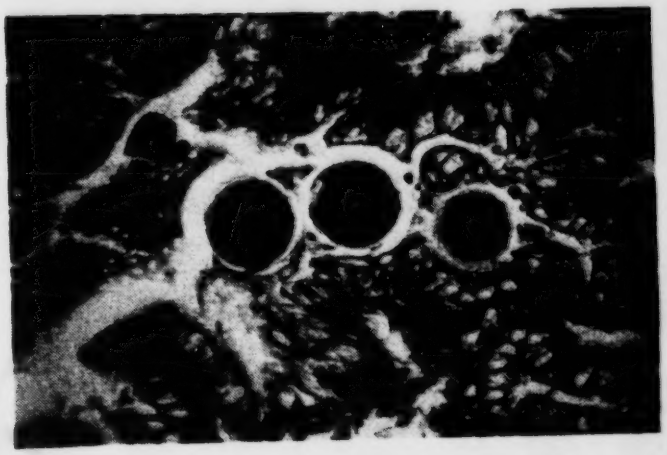


Figure 36

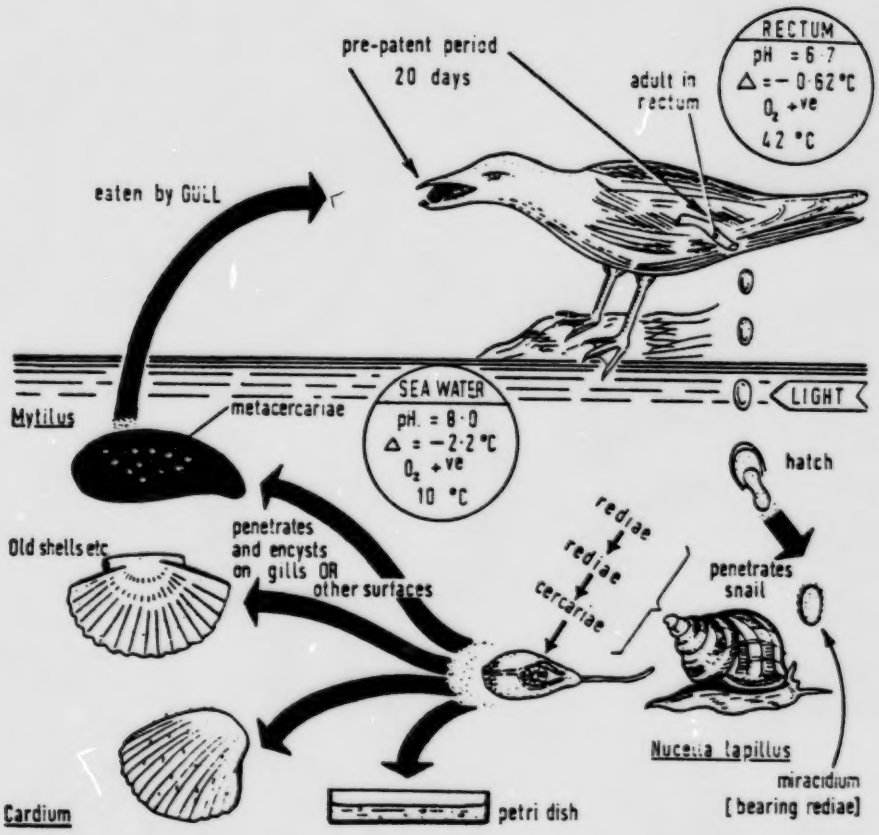


FIG. 70. *Parorchis acanthus*—life cycle and some physiological factors relating to it (original).

Reference: Smyth,J.D. 1962. Introduction to animal parasitolgy. The English Universities Press Ltd., London. Page 176.

Figure 27: Diagram of the life cycle of a species of trematode related to the trematode found in Manila clams in British Columbia.

Figure 30: Map of Vancouver Island with the percentage of Manila clams that were infected with pea crabs from the 10 locations indicated.

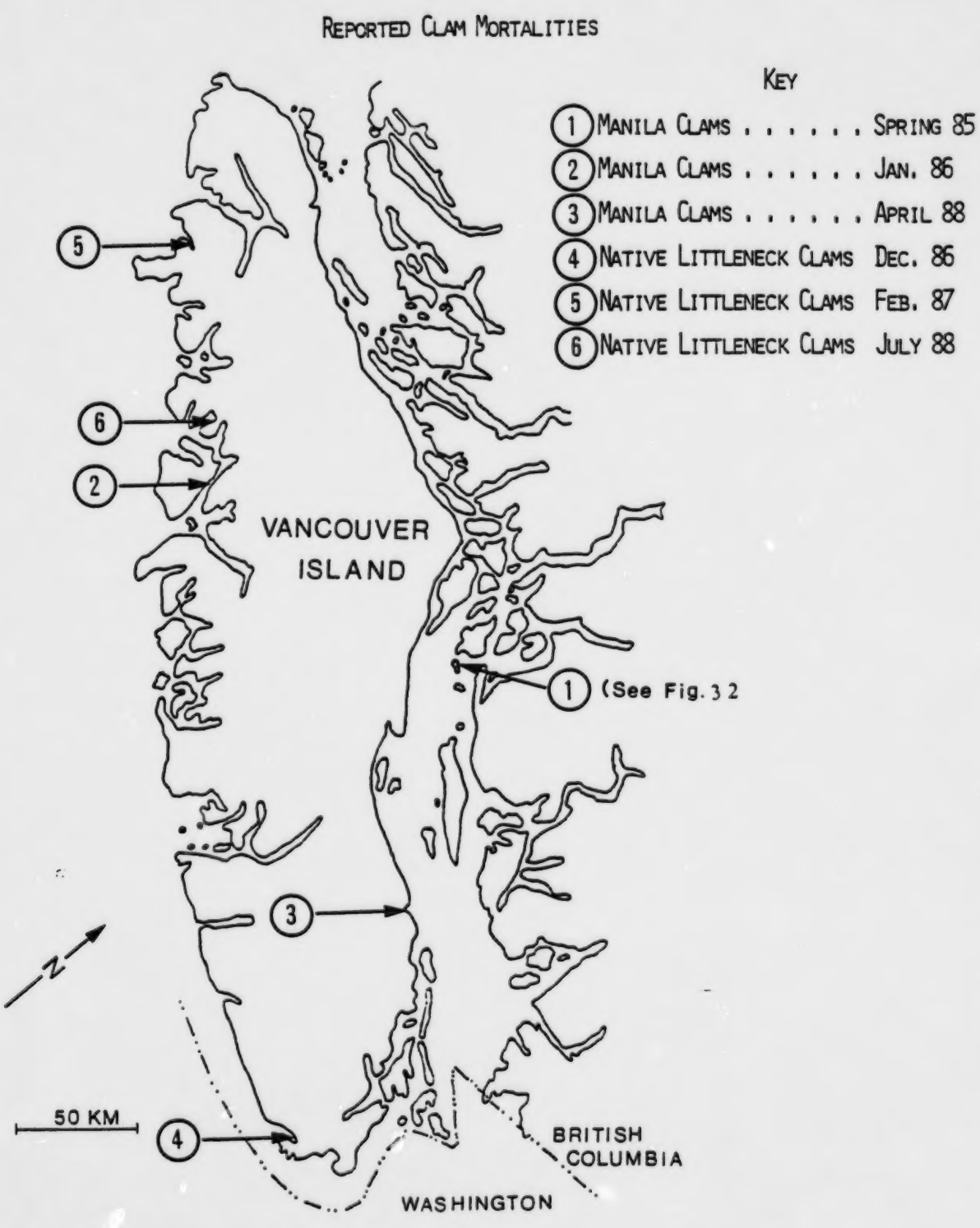

REPORTED CLAM MORTALITIES
KEY
1 MANILA CLAMS . . . . . SPRING 85
2 MANILA CLAMS . . . . . JAN. 86
3 MANILA CLAMS . . . . . APRIL 88
4 NATIVE LITTLENECK CLAMS DEC. 86
5 NATIVE LITTLENECK CLAMS FEB. 87
6 NATIVE LITTLENECK CLAMS JULY 88
VANCOUVER ISLAND
(See Fig. 32
N
50 KM
BRITISH COLUMBIA
WASHINGTON

Figure 31: Map of Vancouver Island with the localities, dates and main species of clam that have experienced unusually high mortalities since 1985 indicated.

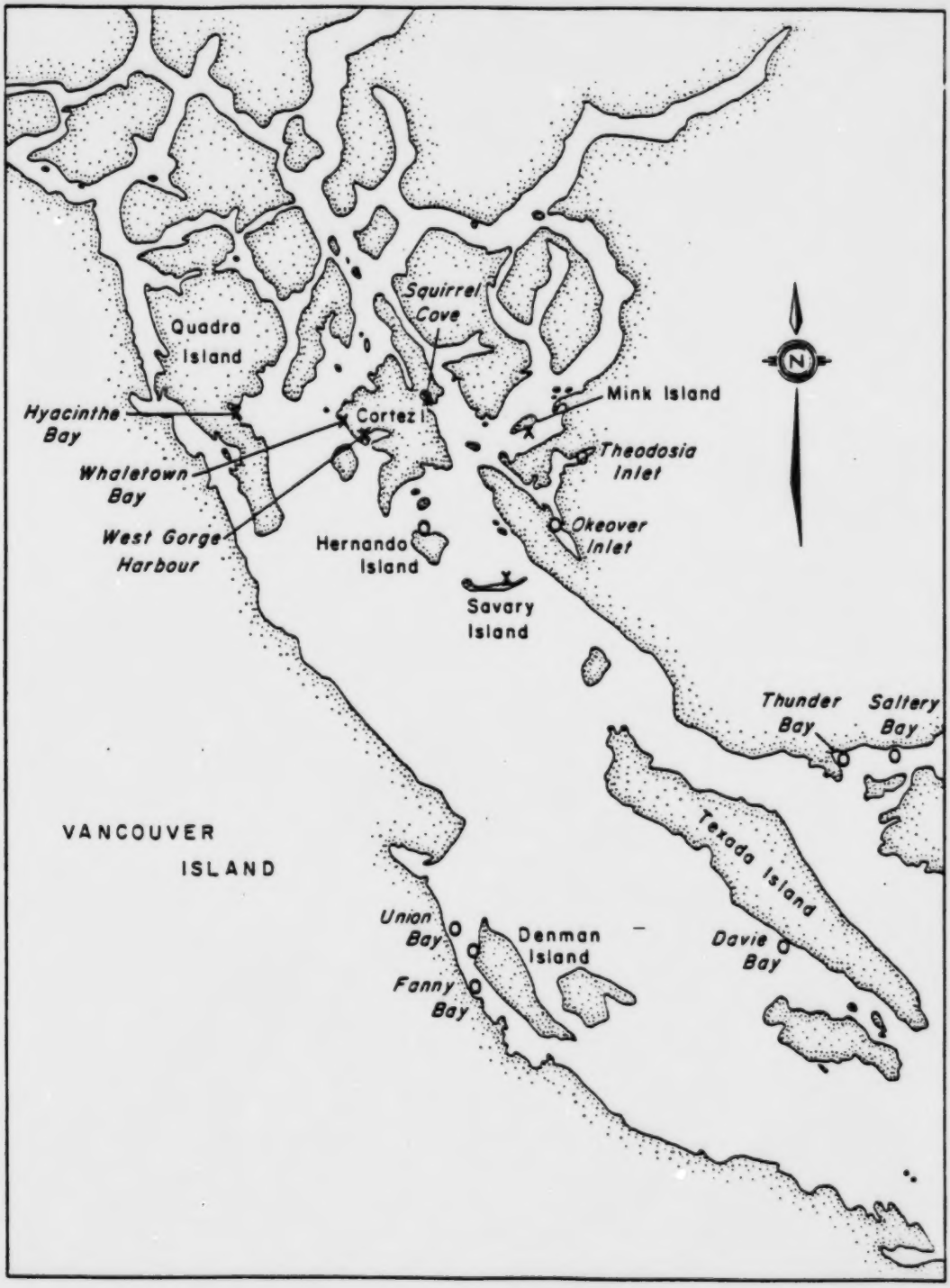


Figure 32: Map of the north end of the Strait of Georgia with 6 beaches reported as having unusually high Manila clam mortalities during March, April and early May, 1985 indicated by X. Beaches apparently showing no unusually high Manila clam mortalities during the same period are indicated by O.

$10,000 fine for polluting

The Canadian Press

CAMPBELL RIVER — CIP Inc., which operates a paper mill at Tahsis on northern Vancouver Island, was fined $10,000 in provincial court Tuesday on a pollution charge laid after a chemical spill last January.

Between 700 and 2,200 gallons of chlorophenate, a toxic chemical preservative, spilled from CIP's mill operation into Tahsis Inlet. The pollution charge was brought by the federal fisheries department.

In addition to the fine, the company has been ordered to take immediate steps to install pollution safeguards at the Tahsis mill, including removal of a dip tank by Dec. 31, 1989.

Figure 33: Copy of newspaper clipping from the Victoria Times-Colonist on December 17, 1986 that reports a fine levied against a paper mill at Tahsis for dumping toxic chemicals.

MANAGEMENT OF MANILA CLAM DISEASES IN INTENSIVE HUSBANDRY

Dr. Ralph Elston, Battelle Marine Research Laboratory

INTRODUCTION

I am going to talk about health management in hatcheries and nurseries because that is where we can really make an improvement, manage health and help prevent mortalities that reduce productivity. I'll give an example of 3 or 4 husbandry diseases that can affect the animals when they are under intensive culture. Stress on the animals in culture tends to bring out such diseases. There has not been a lot of attention paid to clam health management because until recently, although there have been clam harvests, there has not been, at least on the west coast of North America, a lot of interest in intensive culture of clams.

My understanding is that the culture of clams is probably more advanced on the east coast of North America than in other parts of the world and as a general rule, my experience with those hatcheries is that as far as infectious diseases are concerned, clams tend to be relatively healthy. They are not subject to a variety of the diseases that have affected oysters and some of the other animals that are known. A variety of hard shell clams seem to be fairly amenable to culture. There are some diseases of early life stages which I will mention and also there have been some problems with toxicity in early life stages. In one case on the east coast we think a problem in culture was linked to tributyl tin (T.B.T.) which most of you probably know is a highly toxic compound to adult bivalves. It can also affect the early life stages and it has an effect on the shell formation as well as the adults but it is quite a different effect. You actually get a rolling out of the shell periphery, a scrolling, even at very low levels.

I will discuss two known diseases of clams. 1) Hinge ligament destruction. As you are aware, the two valves in a bivalve are held together by a hinge and that hinge is responsible for the ability of the valves to separate as a spring. 2) Geoduck flagellate disease. This is a disease that we have found in the intensive culture of geoducks in which the Washington Department of Fisheries is engaged. I also want to talk about surface coating bacteria in mollusc culture. This is really not a disease, per se, but a condition of husbandry which can be controlled and the negative effects of it can be prevented. Finally, I'll conclude with some general remarks on health management and disease control in molluscs.

EXAMPLES OF CLAM DISEASES IN INTENSIVE HUSBANDRY

With respect to the hinge ligament problem, over the last fifteen years I have looked at many cases of juvenile mortalities because these have been sent into the laboratory from various locations in North America. I began to notice in 1983 that there was a very uniform pattern in these in terms of what the problem was (Table 7). A variety of species were affected including Pacific oysters, American oysters, hard shell clams from the east coast, flat oysters, razor clams and Manila clams. The

consistent lesion was the loss of the hinge ligament in virtually every case. In one representative case (Table 7) which happened to be oysters but was typical of Manila clams as well, the surface of these animals are covered with bacteria. That is not too surprising because if you want to find bacteria in the marine environment, you look on surfaces. You usually find that surfaces are covered with bacteria. Significantly, we also found a high percentage of the bivalves had destruction of the hinge ligament and this destruction was correlated with problems that probably resulted from that destruction. Once the ligament is gone, the valves don't open in a spring-like fashion. The animals can't feed - they can't respire properly - they may become subject to other diseases as well.

Thus I initiated a project for a graduate student (Mr. Christopher Dungan) to pursue this further, his project was finished about a year ago. I will describe his findings to you. Figure 37 is a greatly magnified cross section of the normal hinge ligament.

Figure 38 by comparison, shows where that hinge ligament should be. The hinge has been completely eroded by a very specific type of bacteria. The interior organs of the animal are still intact and it is still alive but it's ligament doesn't operate properly. As I mentioned, the shell opens passively by the effects of the ligament and it closes actively by the effects of the abductor muscle. Thus with the abductor muscle still intact, shell closure is fine but the valves aren't going to open since the ligament is destroyed.

An experiment was done where Mr. Chris Dungan took hinge ligaments from adult oysters, sterilized them and put them in a test tube and demonstrated that specific bacteria (gliding bacteria) that were obtained from hinge ligaments are capable of using the ligaments as a sole source of nutrition to grow on whereas other bacteria are not. This means that there is a group of these gliding bacteria that have evolved in the marine environment to grow on oyster, clam, and other types of bivalve hinge ligaments. Thus, it is a very specific relationship. Next Mr. Chris Dungan took a number of hinge ligaments from healthy oysters, put them in test tubes, and showed that when these test tube cultures were inoculated with this gliding bacteria, that at all the temperatures he tested (5 to 20 deg. C), they would have an effect on the resiliency of the ligament. The ligament should be resilient and flexible when it is wet. When it is subjected to the effects of these bacteria the ligament becomes softened, gelatinous and eventually liquefied and essentially non-functional. The effect is somewhat dependent on temperature. There is not such a great effect at 5 degrees Celsius but above that you get a uniform effect on up to the high temperatures.

A second disease of cultured clams is one that is caused by a protozoa (a single celled parasite). This disease demonstrates that through good husbandry practices a disease can be eliminated. Dr. Hal Beattie could comment on what effect the disease is having currently but in the first few years of culture of geoduck larvae there were serious losses, up to 100%, in the earliest spawns in springtime, March through May. Typically when larvae get sick, you first see them on the tank bottoms. Of course, this is a completely nonspecific indication in terms of

telling you what exactly the disease or cause is but it is an indication that you really should have a closer look. We found what we call vacuolated forms, which are the parasites within the valve of the clam (Figure 39). The parasites, which are actually known as flagellates, are getting in the shell and they are attacking live animals. They get in by going through the mantle to get into the body cavity of the larvae quite the same way that certain other bacteria can cause disease in larvae. The mantle seems to be a weak link in the early bivalve life stages. It is really a terminal disease for larvae because the mantle is laying down the new shell. If the edge of the mantle is destroyed the larvae are not going to grow. They apparently don't have a great capability to repair their tissue in those early stages whereas an older clam or oyster would be able to endure some of these insults and repair the tissue.

Now I will demonstrate a condition I noticed in the northeast about 8 years ago in some clam/oyster culture among three species, the flat oysters, American oysters and also eastern hard shell clams (Mercenaria mercenaria). In the seed oysters (Figure 40), about a centimeter in shell height, the edges of the valve are not normally calcified. As I think you know, shell formation is started when the oyster or clam secretes a protein envelope. Subsequently, inside that envelope you get calcification. Thus, the shell forms and, in some species, the protein envelope completely disappears. Figure 40 shows the failure to complete the calcification step in oysters. Figure 41 is a representation of the highly magnified edge of the oyster shell taken with an electron microscope. You can see bacterial cells growing on the surface of the shell. There is a close correlation between the accumulation of these surface coating bacteria on the shells in the hatchery and the inability of the oysters and clams to calcify the shell. Thus, a potential solution for this problem was to look for ways to control the bacteria that were on the surfaces of the bivalves and all surfaces in the culture (e.g., the tank surface, water line surface). The hard shell clams were cultivated at temperatures that were probably fairly high compared to what we are doing with some of the other clams regionally. In this particular operation with these hard shell clams, they were trying to maximize growth at about 27 degrees Celsius. This temperature seemed to be optimal in terms of growth. What we found when we isolated these bacteria and examined their growth response according to temperature is represented in the top panel of Figure 42.

This shows an experiment to test, at various temperatures, the growth rate of these bacteria that came from the shell surfaces. We found that the bacteria had an explosion of growth between 25 and 30 degrees Celsius as shown by the peak for bacteria 25-1 in Figure 42. This suggested the possibility of controlling this disease by sacrificing some of the growth that was obtained at 27 degrees Celsius by reducing the temperature down to about 24. When the water temperature was lowered, the quantity of these bacteria on the surfaces was dramatically reduced and the problem seemed to disappear. The important point here is that when you are growing animals in a hatchery or a nursery you have a dynamic situation, a small ecosystem. You are also growing bacteria, and various other microorganisms. You must look at all of these components to understand their interactions. This is an example of an easily observed interaction between a bacteria and the bivalves that you

are trying to grow. Since the bacteria has evolved the ability to grow at this temperature, you must realize that you need to manage it by lowering the temperature. This controls the bacteria and even though you lose a little bit of growth by temperature reduction, your final production output is going to be a lot higher since the bacteria are under control. I am not saying these bacteria are going to occur in every environment. Also, the optimal temperature for growth of bacteria will depend on the region.

MANAGEMENT OF CLAM DISEASES IN THE HATCHERY AND NURSERY

I will mention some general items and a few specifics for health management. There are really two categories of diseases that you need to be concerned about. First, there are exotic diseases that occur somewhere else in the world but not in this particular region and cause significant problems. It will benefit everybody to avoid the introduction of such diseases. Secondly, we have husbandry diseases. These are the conditions I have been talking about. With respect to exotic diseases, you want to prevent their introduction. Husbandry diseases are caused by microorganisms that are potentially present in all environments so you've got to continuously pay attention to managing them.

If you are operating a nursery or hatchery system you must manage the bacteria in the system, so that it does not cause a husbandry disease. Such management is really a logical process. For example, if we want to understand a bacterial problem in a hatchery system, you've got to understand the places within that system where bacterial contamination can originate. The components of bivalve mollusc husbandry are the brood stock, the algal feed that you are culturing and the bacteria included with those algae (Figure 43). Some of those bacteria are beneficial but others are potentially pathogenic. You also have a source of seawater and a seawater system. All three of those are potential sources of bacterial contamination. By process of elimination, if, for example, you've got a surface coating bacterial problem, you can look at these by bacteriological culture methods in order to find out what the source of the bacteria is. When you use the process of elimination for bacteriological sampling, you need to look at surfaces of pipes and tanks as well as the other system components. You may find bacteria in the water column as well. Bacteria may be attached to algal particles since many bacteria have an affinity for attaching to surfaces. Thus, surfaces can actually be the cells of living algae.

Experience has shown that any one of the system components can be a source of bacteria. A particularly critical point in the process is metamorphosis, or settlement. Any species, even if it doesn't attach to substrate, is going to be affected by the coating of bacteria on the settlement surface.

We can list a number of ways to prevent and manage bacterial infections (Table 8). You must maintain pathogen free algal stocks if you are producing algae. This doesn't mean bacteria free, but it means free of problem causing bacteria. Vibrios are a category of bacteria which must be minimized in the system. These are really the "weeds of the sea" but

they can cause diseases in husbandry if they are allowed to proliferate.

If a serious disease problem occurs in a hatchery or a nursery caused by some bacteria or other microorganism, you want to isolate it to keep it from spreading to other parts of the system. If you really have a serious problem, you may need to discard some of the sick animals and pay some attention to sterilizing the tanks or the screens that are associated with that problem. These steps are summarized in Table 9.

I would like to summarize what clam culturists can do to help solve their disease problems when they seek professional assistance. One of the basic problems that we have in trying to provide assistance is that a culturist will bring in animals "from a mortality" but it will actually be after the mortality. We really need to have a chance to examine these during the mortality. You need to be concerned with taking appropriate samples when the mortality is happening and submit these to a qualified shellfish pathologist. One of the most useful things in terms of tracing the cause of a disease is to have some record of mortality, a record of what animals have moved into the system, what the densities have been and pertinent information such as temperatures. When animals come into the laboratory for examination we try to observe them in the laboratory situation alive. Once we have done this we can perform various types of examinations such as making and examining the microscopic slices of tissue and making bacteriological cultures. There isn't always an evident answer but the point I would like to emphasize is that without appropriate and timely samples from the culturist a laboratory can do nothing to help. If you perceive a recurrent and serious problem, get the samples out when it is happening at the appropriate time.

I will close with a few points regarding animal movements. This is an issue everywhere. My opinion is that the movement of shellfish for commercial purposes is inevitable. It happens every day between continents and within continents. There clearly are risks as mentioned but we can and must do things to reduce those risks. My view would be that we should not take an extreme view on either side of this issue. We don't want government to attempt to completely limit the movement of animals since it wouldn't then be possible to operate commercially. On the other hand we don't want to move shellfish around without any consideration to the fact that they can transmit diseases because we know that on some occasions, introduced diseases can be devastating. The way to reduce this risk is to develop a historical evaluation of disease problems of shellfish from particular localities and to have the tissues of the shellfish examined for the presence of potential disease causing microorganisms. If you take these steps, you can reduce but not eliminate risk.

What we are really trying to accomplish as shellfish pathologists is prevention and management of diseases and in some cases, perhaps, eradication. It is important that industry and government see their goals as being identical on this issue. It really is in everyone's best interest to control the effect of shellfish diseases. This doesn't mean that we have to completely eliminate the movement of shellfish. The industry needs to recognize that there is a risk and to make certain that everyone in the industry recognizes this risk and apply peer

pressure to prevent irresponsible actions by some individuals. Regulatory agencies need to avoid taking an extreme conservative view that shellfish shouldn't be moved at all and to take some steps to formulate better ways to reduce the risk. Our methods for looking at diseases in shellfish are primitive compared to the methods that are used in veterinary or human medicine and we are trying to improve those to get better methods.

One of the recurrent problems experienced in terms of movement of shellfish is an issue that we deal with commonly in Washington. For example, if someone wants to move shellfish into Washington, we may not have any information on whether a particular disease which the shellfish may carry is already in Washington or if it is in the shellfish proposed for importation. You can't make an intelligent decision on whether there is a risk in moving shellfish from one area to another if you don't have such information. In order to make these kind of decisions we need an inventory of shellfish diseases. We are beginning to develop this type of information but more is needed. We also need to know the species that are affected, the seasonality of the conditions and how to diagnose them.

One of the most important things we need to do is to prioritize health and disease problems so that government and universities can make appropriate decisions about where to expend their research resources.

Editor's Note : Table 7, 8 and 9 and figure 43 reprinted with permission from Elston, R.A. 1984. Prevention and management of infectious diseases in intensive mollusc husbandry. J. World Maricul. Soc. 15:284-300. Figures 37 and 38 reprinted with permission from Dungan, C.F. and R.A. Elston. 1988. Histopathological and ultrastructural characteristics of bacterial destruction of the hinge ligaments of cultured juvenile Pacific oysters, Crassostrea gigas. Aquaculture, 72:1-14. Figure 39 reprinted with permission from Kent, M.L., R.A. Elston, T.A. Nerad and T.K. Sawyer. 1987. An Isonema-like flagellate (Protozoa:Mastigophora) infection in larval geoduck clams, Panope abrupta. J. Invert. Path. 50:221-229. Figures 40, 41 and 42 reprinted with permission from Elston, R.A., E.L. Elliot and R.R. Colwell. 1982. Conchiolin infection and surface coating Vibrio: shell fragility, growth depression and mortalities in cultured oysters and clams, Ostrea edulis and Mercenaria mercenaria.

Table 7: Bacterial infections and lesions in larval and juvenile bivalve molluscs from field cases in commercial production facilities. A detailed example of one observed instance of an infection pattern from Crassostrea gigas juveniles is shown in columns 4 through 7.

Species	Stage	No. of instances observed[a]	A Typical Example of Observed Lesions			
			Proportion of 93 Animals With			
Crassostrea gigas	L	2				
C. gigas	J	10				
C. virginica	L	1	Shell surface bacteria	Ligament infections	Pallial infections	Branchial systemic infections
C. virginica	J	1				
Mercenaria mercenaria	J	6				
Ostrea edulis	J	3	93/93	14/18	44/91	8/39
Siliqua patula	J	1	(100%)	(78%)	(48%)	(21%)
Tapes japonica	J	3				

[a]Each instance represents a separate production group of animals with either spatial or temporal separation or both from any other reported group.

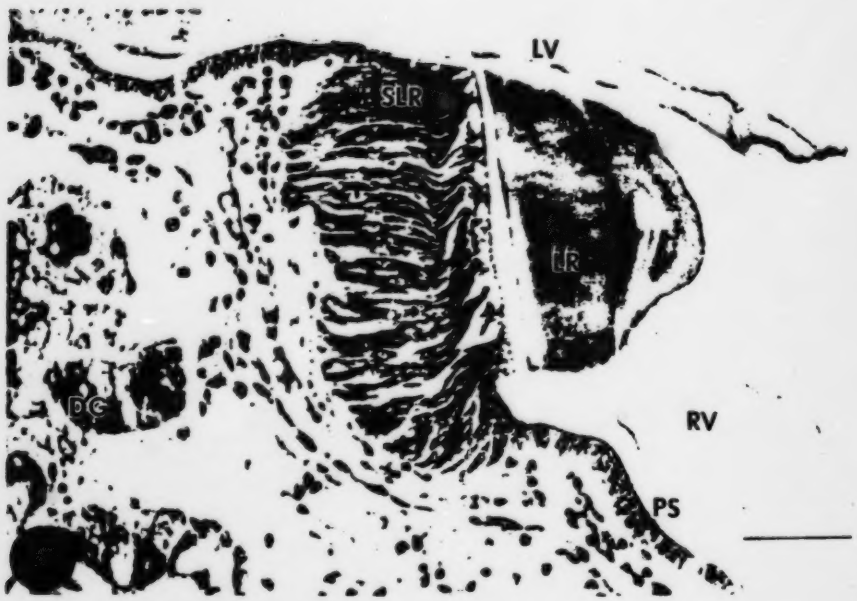


Figure 37: Normal morphology of the hinge ligament and associated tissues in juvenile Crassostrea gigas. Transverse histological section through the hinge ligament resilium (LR), secretory subligamental ridge (SLR), pallial space (PS), left valve (LV), right valve (RV) and digestive gland (DG). The SLR is intimately apposed to the internal surface of the resilium. Neither the resilium nor the pallial space is colonized by bacteria. Bar = 100 micrometers.

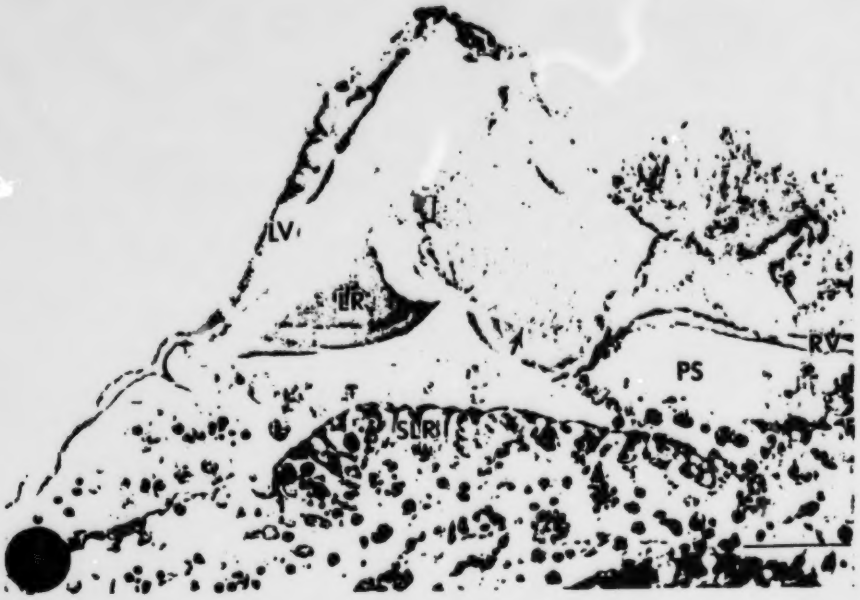


Figure 38: Affected juvenile oyster whose hinge ligament has been nearly perforated by bacterial erosion. Transverse histological section through the hinge ligament resilium (LR) which separates the left (LV) and right (RV) valves. Ligament-eroding bacteria appears as fibers oriented at right angles to the eroding resilium margin (arrow). The SLR appears necrotic, and is separated from the internal resilium surface by a wide pallial space (PS) containing bacteria and free oyster cells. Bar = 100 micrometers.

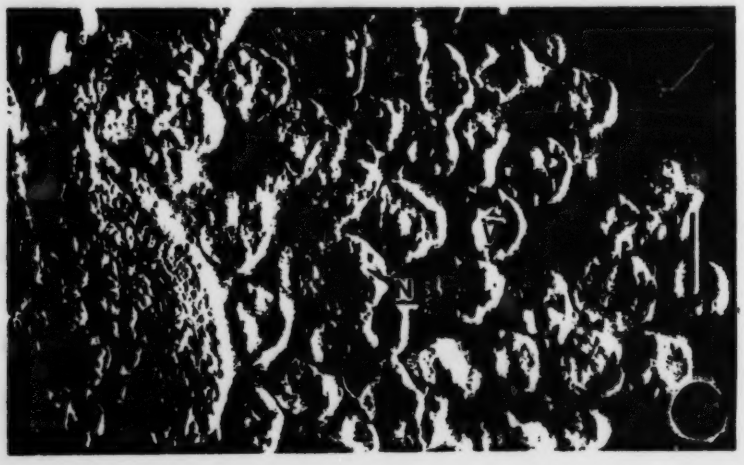


Figure 39: Wet mount preparation of moribund geoduck Panope abrupta larvae heavily infected with Isonema-like flagellates. N, nucleus; V, cytoplasmic vesicle. Bar = 20 micrometers.

Figure 40: Juvenile European oysters. Note the clear, uncalcified areas of peripheral periostracum and the fragmentation and dislocation of these areas. Both specimens show extensive areas of chalky deposits and lack of uniformity in the degree of calcification. Bar = 1 mm.

Figure 41: Scanning electron micrograph of enclosed area in the peripheral shell area of a juvenile oyster. The folded-back surfaces of periostracum form elongate tears. Bar = 1 micrometer.

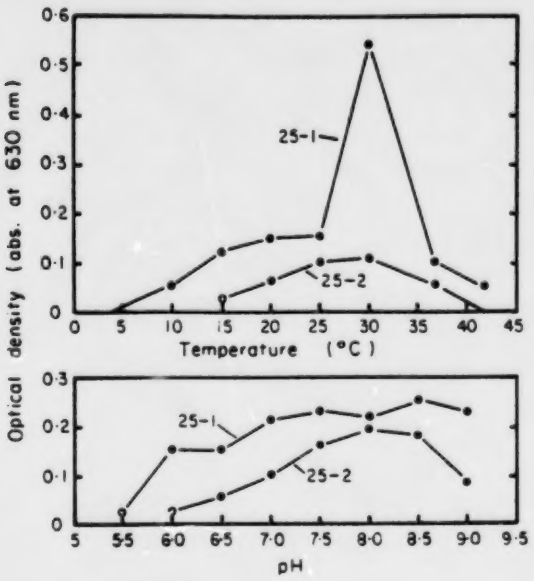


Figure 42: Growth response of isolates 25-1 and 25-2 to variations in temperature and pH. Isolate 26-1 showed nearly identical responses to 25-1. Closed circles represent growth measured spectrophotometrically after 18 h incubation. Open circles represent growth undetectable as specified above, but that which was observed visually after up to one week at the specified condition. Temperature determinations made in medium of pH 7.5; pH determinations made at 25 degrees C. All points represent average of three uniformly inoculated tubes.

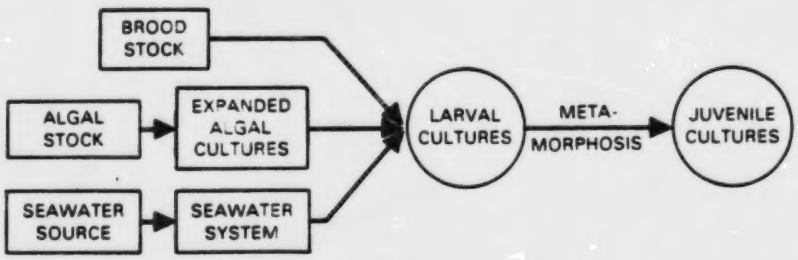


Figure 43: Conceptual diagram of an intensive mollusc husbandry system.

Table 8: Prevention and management of bacterial infections.

Maintain pathogen-free algal stocks and expanded cultures.
Maintain absence or low levels of vibrios in the system (water column and surfaces). - Use appropriate degree of water filtration. - Maintain hygiene of system surfaces. - Use appropriate frequency of water changes.
Isolate infected stocks and associated equipment at first sign of clinical disease.
Discard infected stocks and sterilize equipment.
Identify source of infectious organisms, and modify and clean system.

Table 9: Husbandry system management of animal stocks which may carry infectious diseases.

Separate and isolate brood stock before, during, and after spawning, until confirmatory diagnosis is made.
Separate suspect larval and juvenile cultures from other cultures.
Use separate handling equipment and procedures for each stock.
Destroy infected cultures and source brood stock upon confirmatory diagnosis of disease.
Sterilize effluent from suspect brood stock or culture.

AN ABRIDGED HISTORY OF SHELLFISH CULTURE IN WASHINGTON STATE

Mr. Doug Magoon, Department of Natural Resources

BACKGROUND - THE OLYMPIA OYSTER INDUSTRY

In about 1850, the first oystermen moved into Willapa (Shoalwater) Bay. At the time, the native or Olympia oyster formed great reefs on the sand and mudflats along the channels. Willapa has some 47,000 acres of tidelands out of a total of 88,850 acres.

Initially, this was a wild harvest industry with no thought to either culture or preservation. The local Shoalwater Indians were hired to load the oysters into canoes and then into trading schooners for transport to San Francisco. The rich 49ers were willing to pay something like $5.00 a plate at a time when a dollar a day was good wages.

Over the years, the natural oyster habitat in Washington was destroyed - shipped off to San Francisco, buried as a result of logging the surrounding watersheds or destroyed by other human activities. The vast oyster beds in Budd Inlet at Olympia were killed by a sawmill located on the tideflats.

OLYMPIA OYSTER CULTURE

In the late 1800's and early 1900's as the wild stocks of Olympia oysters became depleted, the oystermen began to experiment with culture methods. A successful culture method was developed in the protected bays of South Puget Sound, thus extending the life of the Olympia oyster industry for a couple of generations. The patient eventually died anyway - the victim of an improperly located pulp mill, the introduction of pests like the flat worm and the Japanese oyster drill and the internment of the Japanese labor force during World War II. However, in culturing the Olympia oysters, the oystermen were developing acres of ideal habitat for the soon to be introduced Manila clam.

The Olympia oysters are very susceptible to extremes of hot or cold. While climate conditions in western Washington are usually quite mild, it only takes one hard freeze or hot day in the oyster's five year growing period to spell economic disaster for the oystermen. To insulate against the temperature extremes, the oystermen built low dikes of wood and later cement around the three lower sides of gently sloping tidelands. The dikes created shallow ponds which insulated and protected the oysters.

In instances where the tide land was composed of soft mud or sand, the area was firmed up by adding a layer of gravel. Sometimes a layer of boards were laid down first but usually the gravel was unloaded directly from a barge onto the tideland. A layer of Olympia oyster shell or clam shell, a foot or so thick, was then added to provide a substrate for the Olympia larvae to set on. Over the years, this gravel and shell layer became quite substantial as more and more layers of shell were added.

ENTER THE JAPANESE OYSTER

The only hope for the survival of the Willapa Bay/Grays Harbor oyster industry was the introduction of a new species. The Eastern oyster was introduced into Willapa Bay in the 1890's. They never really did well and were eventually replaced by the Japanese oyster. The Japanese, or Pacific, oyster was introduced into Willapa in the early 1920's. The newcomer proved to be virtually bomb-proof. Once established, the Japanese oyster proved more versatile than the native oyster. The Pacific oyster grew much faster and was tolerant of heat, cold and a high silt content in the water. By competing both physically and economically, the introduction hastened the decline of the remaining Olympia culture. Thus, the Japanese oyster replaced the Olympia oyster as the primary shellfish grown on the West coast. It was widely cultured in Puget Sound by the mid 1930's and had generally replaced the Olympia oyster by the mid 1940's.

ENTER THE MANILA CLAM

The Manila clam or "Japanese" littleneck was probably introduced along with the early shipments of Japanese oyster seed. Unlike the oyster drill and the flatworm, this introduction proved a very happy one. This clam did not compete with any native species, reproduced well, grew fast, had a good flavor and fit into an existing market for steamer clams.

Habitat

Manila clams have very short necks, hence, they are typically found very close to the gravel surface. Because they occur close to the surface, they need very stable ground. They are active diggers throughout life and have some ability to rebury themselves; but as they get larger, the gravel substrate limits their ability to dig. A substrate that is continually moving requires so much energy the clam is unable to keep buried and they fall victim to predation.

In Japan, the Manila clam occurs both intertidally and in shallow subtidal areas. However, on the west coast of North America, it occurs most frequently in high intertidal areas above the elevation of the native hardshell clams, such as the native littleneck and butter clams. This narrow habitat range is probably due to some predator or group of predators that developed an intertidal range corresponding with the native clam populations and have been unable or not had time to adapt to the extended ranges of the Manila clam. The Manila clams have been grown successfully in suspended trays in 20-30 feet of water; so water depth itself is not the controlling factor.

These high intertidal areas tend to be the portion of the beach subjected to heavy wave action and significant substrate movement. Thus, the Manila clams are usually restricted to quiet bays, especially the heads of bays. Places where mud settles out naturally, are good candidates for Manila clam habitat provided there is some gravel

available.

The best habitat seems to be a pea gravel beach with a high mud content, a high shell content and a good water flow past the clams. Whether the high shell content is a result or a cause of the clam bed is unknown. One 8 acre beach with a 200,000 pound annual production is virtually 100 percent shell.

Some of the best Manila clam grounds proved to be the old Olympia oyster grounds where the mud had been covered with gravel and shell. The remnants of the old oyster dikes help break the wave action, keeping the area stable.

THE CLAM FISHERY

Clams of all species have historically been the oyster's poor relatives. They were very abundant and widely distributed for all to take. They were harvested commercially when markets could be found. Few individuals attempted to culture clams, other than just digging the beach, which usually does improve settlement and growth. Prices for both oysters and clams were severely depressed in the decades following World War II, because of foreign imports and the huge east coast shellfish industry which supplied most of the country's needs. During the late 1970's, the east coast industry for both clams and oysters began to decline rapidly. Disease, over harvest and pollution decimated many beds and closed many others. As the market opened up, prices and interest in western oysters and "steamer" clams, especially Manila clams, began to rise dramatically.

At about the same time, shellfish hatcheries began to come into their own as a stable, economical source of seed. Manila clams proved to be quite adaptable to hatchery culture. Thus, clam seed became available for experimental and cultural use.

The increased demand for Manila clams increased both the value of the clam stock and the amount of harvest all along the west coast. The present harvest has reached a point that is probably not sustainable without the advent of intensified culture and expansion of available clam growing areas.

MANILA CLAM CULTURE

As with any type of farming, the farmer who knows his ground intimately and knows the species being propagated will best be able to modify the cultural techniques used to fit a particular area, thereby increasing yield.

Improving Existing Habitat

In some instances, one of the easiest ways to improve an existing clam bed is to dig, rototill or harrow the area to get water flowing through the substrate. This action will bring the gravel to the surface and get rid of any black silty (anaerobic) areas. While some clams will grow in

an anaerobic beach, mortalities are high and setting is poor. Such areas probably should not be seeded until the beach has regained its healthy, brown color.

One old Japanese method of increasing natural clam set involved anchoring brush over the clam grounds. Local clam growers have found that Christmas trees work very nicely in this respect.

Some local clam farmers are seeding their natural beds. While there is no guarantee the unprotected seed will survive to commercial size, there are, assuming good survival, some advantages. This method assures there is sufficient seed in the beach to begin with. Even good clam areas do not get sufficient seed settlement every year. Chances of over populating a beach by seeding are usually much lower than the likelihood of the natural set producing less than the desired number of harvestable clams.

Much of the seeding is done after the beds have been dug. Spring seeding seems to work best; it allows the seed to start growing immediately. When seed is planted in the fall or winter, it will not start growing until spring and is subjected to an added period of predation. Please note that when planting seed on a sunny day, keep the seed moist because dry seed will float away on the incoming tide.

On some beaches, a yearly planting makes it possible to have more than one generation of clams growing on the beach. Digging causes a loss of juvenile clams but if done with care, these smaller clams are usually able to survive. It is important that clams not be deeply buried during the process. Clams must be able to right themselves and reach the surface.

Adding Gravel

Mud is generally very poor Manila clam habitat though the occasional clam can be found growing there. Manila clams, even large Manila clams, have a single byssus thread which is attached to a piece of gravel or other object buried beneath the clam. This byssus thread is not as strong as those of the blue mussel but it is strong enough to support the weight of the clam. The thread serves to anchor the clam in the substrate and may aid in digging. Adding gravel to a muddy substrate will often make good Manila clam habitat. The most successful graveling operation appears to be those that add a thin layer, say an inch or two, and repeat the process over a number of years. The gravel provides habitat without smothering the beach and turning it anaerobic (black). Once the clams are dug, another layer of gravel is added as necessary to firm up the beach. If a thick layer of gravel is added, life in the underbeach is smothered, the beach turns anaerobic and it may be several years before a significant clam population develops.

Manila clams set and grow in some sand beaches but seldom reach commercial size. They become victims of predation by flatfish, crabs and ducks (usually scoters and golden eyes). Some of these sand beaches can be a good source of seed. However, seed is now readily available from hatcheries.

Protective Netting

One of the newer culture methods has been the addition of protective netting over clam ground. The technique was originally developed by the University of Washington, School of Fisheries. The original experimentation was done on narrow pea gravel beaches, along narrow channels that were subjected to frequent boat waves of moderate magnitude. Most of the experimental areas did not contain clams prior to netting. A one-half inch mesh plastic "car cover" netting was put on the beach and a trench dug around the edges of the netting. The edges of the netting were put in the trench and wooden stakes were driven through the netting at the corners and at intervals of 10 feet. The netted areas were then planted with clam seed. A planting density of up to 1000 seed per square meter for 3 mm seed and 600-700 per square meter for 10 mm seed provided good commercial quantities of adult clams at the normal growth rate for the area.

The netting seems to work by floating up off the bottom, thereby slowing down the current or wave action directly over the bed and allowing silt to settle and stabilize the beach. The netted areas became more siltier and in many instances the net becomes filled full of sand or small gravel. An area which is already muddy or silty will get more so when netting is applied, making it a poor choice as a netting site. A build up of substrate on top of the net will smother the clams so netting will not work in areas of heavy substrate movement.

The netting serves as a barrier for some predators such as ducks, fish and crabs. However, if there is a hole in the netting, the crabs will have a field day. Frequent inspections are warranted.

The netting does not seem to be effective in extending the lower edge of the clam population further down the beach. In South Puget Sound, Manila clams normally grow best in the +3 to +7 foot tide area (i.e., 20-50 percent of the local mean higher high water elevation of 14.4 feet). Juvenile moon snails can get through the netting and grow up along with the clams which may account for poor results when the netting was tried below the +3 foot level.

In areas where it can be used, netting is a good insurance, especially if you are spending money on seed. A modification of the method described is being used by some South Puget Sound clam farmers with good success.

RECOMMENDED READING

A Guide to Manila Aquaculture in Puget Sound; Gregory Anderson, M. Miller, K.K. Chew; WSG 82-4, $3.50. Available from Washington Sea Grant Program, College of Ocean Fisheries Science, University of Washington, Mail Stop: HG-20, Seattle, WA 98195.

NURSERY PRODUCTION OF MANILA CLAMS IN BRITISH COLUMBIA

Mr. Geoff Lindsey, Canadian Benthic Ltd.

INTRODUCTION

Canadian Benthic Ltd. operates the only Manila clam nursery in B.C. This is a sideline to our main business of oyster seed production and as Table 10 indicates is currently a very small portion of our operation. We developed nursery technology for the Manila clam in the early 1980's as a result of a three year Science Council of B.C. project aimed at bivalve nursery culture. Our work demonstrated that nursery rearing of juvenile clams was possible in "off-bottom" systems, however, animals larger than 18-20 mm absolutely required the presence of some form of substrate. This indicated the need for beach culture practices and legal tenures. While nursery culture of the Manila clam proved relatively simple the bureaucracy of beach culture of the resulting seed was mired in federal governmental intransigence. This subject is only now beginning to be resolved and has resulted in a very slow start for the industry and yielded very little information on the culture and husbandry of the Manila clam on the beach.

NURSERY PRODUCTION

The raw material for nursery production is eyed larvae (pediveligers) provided by hatchery operations. Until recently a consistent supply of pediveligers was not readily obtainable. Most hatchery operations had the capability but not the volume of sales to warrant production or if production occurred, it was during the off season and not practical for our small sales volume. Although we have set clams, we generally find it cheaper and more reliable to purchase 800 micron size clams from Kuiper Mariculture in California and nurse then up to the sizes that are practical for grow out operations.

Setting

Settlement of pediveliger clams is accomplished in closed recirculating systems in downwelling tanks, containing silica sand screened to 700 microns. The water is changed by 30% every second day and the sand beds are washed with fresh water every second day. Setting temperature is generally around 28 degrees C reduced to 19-20 degrees C over five days. On the third day the flow is reversed to an upwelling type system. Feeding varies with the number of pediveligers and temperature of the systems but approaches a rate of 100,000 cells per ml three times per day. We like to use algal paste at this stage because it is easy to use and generally clean. The clams are sieved out of the sand when they are 300-350 microns and grown in flow-through upwellers at a temperature of 19 degrees C.

Post Set

When the clams catch on a 500 micron screen they are transferred to upwellers receiving ambient flow-through water and supplemental feeding

of several varieties of live algae every two hours. The algal species that we use are Tahitian Isochrisis, Thallasiosira pseudonana (3H) and Chaetocerous gracilis. Our calculations indicate that each clam receives approximately 0.5 ml algal concentrate per day plus what it can filter from the incoming water. At this stage, we encourage a limited bacterial growth in the enclosing tanks which seems to increase growth rates, presumably acting as a food source. It is important when doing this to keep the shell surfaces of the clams clean with daily washing of fresh water.

The working period for the flow-through portion of our operation is from April 15 to November 15. During this time, we rear the clams from 500 microns to 3 mm screen size. Very little growth occurs after November 15. In this manner any remaining clams are held over to the following spring.

Nursery culture of clams past the 3 mm screen size is generally accomplished in larger in situ upwelling systems similar to that shown in Figure 44. Clams can be grown in these systems up to the 18-20 mm size. Each of these systems is capable of rearing 1 million clams.

Table 11 indicates the approximate growing time that each stage of clam requires in these systems, total growing time to a certain size would be a cumulative total of each preceding time. Thus, a 6-8 mm size seed would require approximately 70 days of nursery culture under the above described conditions. An approximate selling price is indicated for each size class. We sell clams by the 1000 and arrive at the total number through a count of known volume. Counts per ml for each size class are also shown.

CAPACITY

As Manila clam culture at Canadian Benthic is a relatively small part of our business, our capacity is also small. Currently, we can produce approximately 2 million per month in our setting system to the 500 micron screen size. Our intensive nursery operation has a total capacity of 8 million at any one time but staggered production can yield 2 to 3 times this over the April to November season. Our extensive upwelling system is currently capable of rearing 10 million clams to 18 mm and can be easily expanded to 30 million. Due to the size of our setting system and the priorities of oyster setting, we are currently limited to a total capacity of 10 million Manila clams per season. This has not proven to be a limiting number as of yet due to the infancy of the B.C. industry, however, with a more intelligent approach to the issue of beach leasing and increasing grower attention our capacity may well have to increase.

BEACH GROW OUT

It is not the purpose of this presentation to discuss the techniques involved with beach grow out, however, I will outline some of our experiences. Table 10 shows our production and sales as well as number of clams experimented with in grow-out trials. We have not been

particularly successful due to a variety of reasons, chief of which is predation. In our area some form of predator protection is essential and I believe that this will be the case in most other areas. We have tried several methods of beach cultivation including: plastic mesh netting overlaying the seeded beds; seeding into plastic mesh bags; and seeding under oyster cover. In the cases of net and oyster covering we experienced heavy losses due to juvenile Cancer crabs. The only clams which survived juvenile crab attacks were larger than 20 mm. Crabs settled out through the mesh overlay in the late winter after seeding and by early summer had consumed all of the clams in the plot. In the case of mesh bags, the clams were adequately protected from predation, however, the bags were both shallow in depth and too small in mesh size. The bags fast became silted over smothering the juvenile clams and what remained above ground fouled quickly, achieving a similar effect. It now seems that the best method in our area may be a deeper (4-6 inches) bag partially buried in the ground with a mesh size around 1/4 inch.

PREDATORS

Predators of clams are varied and not always obvious. Each size of clam falls prey to one or several types of predators. Awareness and control of predators will be the chief concern of anyone engaging in beach culture of Manila clams. The following is a list of some of the major predators of juvenile clams beginning with those that prey on the smaller sizes up to those that prey on large clams: annelid and flat worms; ghost and mud shrimps; soles; flounders; pile perch; shoveler ducks; crabs (shore through to rock and Dungeness); starfish; and moonsnails. Each of the above can contribute to reduced survival in some areas, however, every beach has it's own set of culture parameters and unique population of predators. As a grower, you must be aware of these factors before you attempt to seed or enhance a beach. Because of the large variety of predators capable of reducing your crop, we do not recommend the purchase of seed any smaller than 6-8 mm in length unless special nursery areas are planned. In general, the larger the seed size the better the survival, however, cost becomes a significant factor when purchasing seed much larger than 6-8 mm.

DETERMINING HOW TO PLANT AN AREA

Four considerations should be addressed when assessing a beach area for seeding:

1) the population structure and size of the native population of clams;

2) the amount of natural clam sets;

3) the size and variety of predator populations; and

4) methods for protection from these predators.

Very little work has been performed in B.C. on the beach culture of

Manila clams. As a result, it is hard to give adequate seeding densities or crop expectations from an area of beach. In general, a good beach is considered to produce approximately 1000 clams per square meter per year. Natural setting densities and survival can vary widely over individual areas. This must be a regular occurrence in the future of any commercial operation as it does not appear economical to culture clams on a put and take basis. A good natural set should provide 70% of each years' seeding requirements. Seed mortality can vary widely with the method of culture and the size and type of predator populations. A seed mortality factor of 50% may not be uncommon.

SUMMARY

The main problem at the nursery level of clam culture is the supply of pediveliger larvae. Most hatcheries are capable of production of clam larvae but because of low demand do not produce in any steady manner. Some problems occur at the post set stage, but in general clams are an extremely hardy nursery product. Improvements in nursery technology for the rearing of 15-20 mm seed clams to allow for lower prices would be a major step forward as this size is much less susceptible to predation. Much more work is required at the grow out level to determine the best technology for reduced predation and increased natural setting.

Question : Are crabs the major predator to clam seedlings?

There are many predators which will affect clam survival, the impact of each depends very much on the size of the seed. For instance, we rear a 1 mm screen clam in a highly intensive system as opposed to the systems described in Figure 44. This is because these larger in situ systems build up predators such as annelid and flat worms which can have a major impact on animals of this size. On the beach, I believe that crabs are the major predator affecting clam populations. Again, size plays a role, shore crabs (Hemigrapsus sp.) will eat small seed up to 30 mm or so at which point Cancer crabs (gracilis, magister, productus) will cause problems with clams up to 35 mm or greater. Generally, the larger the clam the less susceptible they are to the effects of crabs.

Crabs can grow quite fast and we once experienced almost total loss of a seeding trial when Cancer productus (rock crabs) settled into a netted plot. Settlement occurred in January and by late April we had crabs about one inch across under our nets and no clams.

Question : Was your netting placed at any particular tide level?

We had a net strip that ran up from the one foot to five foot tide level. We had hoped to assess growth rates as they varied with tide level. Instead, we determined that crabs know no bounds.

Question : Would a different culture situation in terms of tidal height yield similar results?

In our particular situation, you could have placed the seed right in the trees and the crabs would still cause problems. We have a particularly bad situation with respect to crabs. It is very important that each prospective culturist assess their own situation very carefully as every site is different and will present unique problems.

Question : What is the cost for seed and have you done any work on the most appropriate size of clam for seeding versus price of seed?

I have always said that a seed size of 6-8 mm represents the best bang for your buck, assuming that you have control over your predators. The price of seed is basically $1.00 per 1000 (Table 11) give or take some depending on volume. I do not have a lot of hard data on the cost benefit ratio of seed size as the state of the industry in B.C. is very, very low. I will say that seed smaller than 6-8 mm is extremely susceptible to a lot of problems and even at the nursery level you must be fairly fussy.

Question : Have you ever worked with the Oyster Breeding Cages?

We tried some net cages last year. These were not the Oyster Breeding Cages, but were a lay flat cage. They did not work well at all because they silted over and the clams were not able to migrate up and filter. Clams don't bury themselves deeper than the length of their neck so they are close to the surface when they are small and go deeper when they get bigger. I think that Oyster Breeding Cages might work very well as they have a raised profile and would allow containment of a deeper sediment. I have not used them but intend to try some next year.

Table 10: Manila clam culture at Canadian Benthic Ltd.

YEAR	1984	1985	1986	1987	1988
	(X 000,000)				
SEED PURCHASES	1.45	---	4.08	3.00	
SEED SALES	1.15	---	1.19	2.40	---
GROW OUT	0.20	---	0.50	1.44	
	overwintered		2.53		
	lost at nursery		1.64		
	lost at grow-out		0.85		

Table 11: Key to nursery clam seed at Canadian Benthic Ltd.

SCREEN SIZE (mm.)	SEED SIZE (mm.)	CLAMS / Ml.	$ CDN (approx)	DAYS TO GROW (70%)	
0.9	1	800	2.50	16	
1	1.5	475	3.00	4	
2	2	190	3.50 *	15	
2.5	3	121	3.80 *	7	
3	4	92	4.00 *	8	
5	6	36	7.00 *	20	70
6	9	25	9.00 *	18	
7	12	13	12.00 *	18	

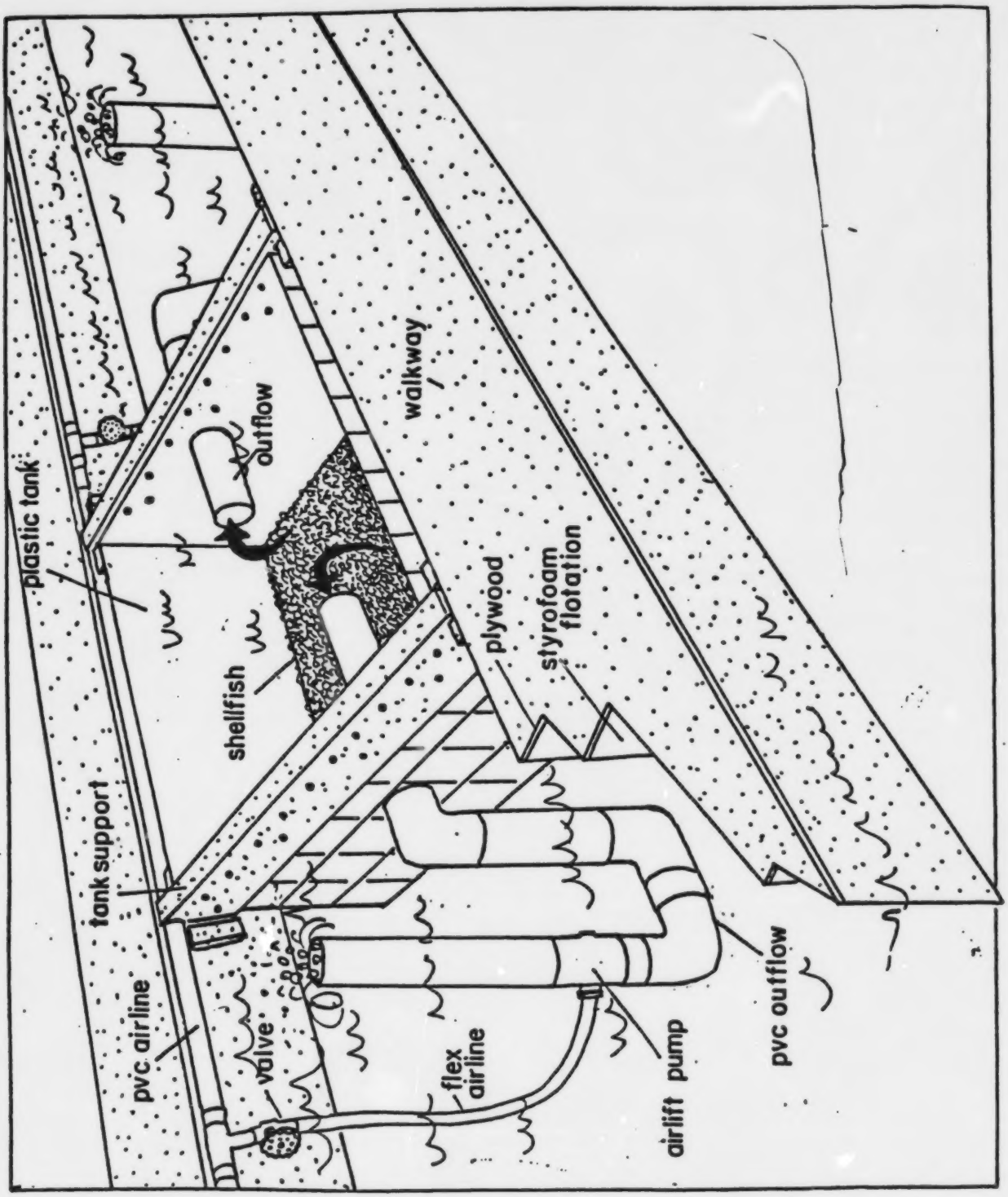


Figure 44: Diagrammatic representation of an upwelling system with the near walkway cut away to show the plumbing arrangement of the outflows.

MANILA CLAM NURSERY REARING AT HUMBOLDT BAY, CALIFORNIA

Mr. John Nickerson for Mr. Ted Kuiper, Kuiper Mariculture Inc.

Kuiper Mariculture Inc. has been in operation at Humboldt Bay since 1980 producing Manila clam seedlings, in addition to Pacific, Kumamoto, and Belon single seed. In response to Dr. Susan Bower's talk, I should say at the outset that our seed is examined histologically three times yearly by California Department of Fish and Game and we have had a disease free history since 1978. We began sales to B.C. in 1982. We purchase most of our larvae from Mr. Lee Hanson (Whiskey Creek Oyster Farm, 2905 Bayshore Rd., Tillamook, OR 97141, tel. 503-842-8365).

I will show a few slides of nursery and grow out techniques, but first I will summarize the types of Manila nursery systems we are most familiar with in our area. For our purposes nurseries are used primarily to rear seed from 2-3 mm to a size that the seed can be planted by the grower at 6-8 mm (bottom culture) or 10-12 mm (bags) for final grow out to market size (35-30 mm). Our niche in the shellfish industry is to provide seed to the growers at a size they can nursery to a larger size themselves or seed that is ready to plant for grow out. The most popular size for bottom planting that we produce is 6-8 mm (Figure 45). For those growers that want to nursery seed themselves, we supply 2-3 mm, 3-5 mm and 4-6 mm (Figures 46 and 47).

SEVERAL TYPES OF NURSERY TECHNIQUES

Upwells

These are suitable for post set seedlings to 2-3 mm. Developed by Mr. John Bayes (Seasalter Shellfish Ltd. The Harbour, Whitstable, Kent, England, CT5 1AB, tel. 44-227-272003, Telex 966293 Oyster G). We culture 96 upwells daily the year round located at two estuarine sites on Humboldt Bay (Figure 48).

Flopseys

Water upwells, developed by Mr. John Bayes, widely used in Europe. Other speakers following me may have photos of these systems. Maine Audubon and Mook Sea Farms have done a terrific job in making the designs for single point mooring flopseys available to east coast growers. This type of system generally requires a site where the raft can swing 360 degrees on the tide, or ready access to electricity for water moving pumps or paddle wheels.

Bottom Trays

Developed by Mr. Don and Mrs. Judy Rogers (Olympia Clam Co., 6331 Murray Ct. N.W., Olympia, WA 98502, tel. 206-866-9401). Mrs. Judy Rogers has a starter kit for growers that want to plant a small amount of seed

on a trial basis. The kit includes 5,000 seed, netting, and a clam manual for $150.00 (*). The plastic trays (2' X 2' X 3") (Figure 49) are lined with fiberglass window screen with a hot glue gun (TG-4C Bostick $40) and the glue is #2125 ($5.00 per pound) from Adhesive Products (tel. 213-589-5516 or Miller Supply, tel. 714-859-2211). Trays are stacked in groups of 4 with a lid, banded (1/2" poly band) and roped (3/8" bk poly) then weighted on the top with concrete blocks. Seed is loaded at 10,000-15,000 2-3 mm (1410 sorting screen) and then handled every 4-6 weeks to cull off 6-8 mm and 10-15 mm seed. I recommend this type of nursery to growers with hard bottom, low to medium silt loads, low level of storm wave exposure and low conflict with recreational users.

Raft Trays

We use this type of nursery exclusively to raise seed from 2-3 mm to 6-8 mm or 10-12 mm. Ten rafts (12 ft. X 20 ft.) with 24 rebar enclosed slots (cells) are moored in a location where we have high tidal current (1 to 4 knots) at a water depth of 12' at low tide (Figure 50). Water temperature varies from 4 to 24 degrees C and salinity 15 to 34 parts per thousand. Rafts are moored cross to the current for maximum circulation in the trays. Trays are the square plastic (2' X 2' X 3") available from the Innovative Aquaculture Prod. Ltd. (Skerry Bay, Lasqueti Island, B.C. V0R 2J0 tel. Parksville Mobile N497564-CH YR) or Mr. Randy Shuman (AMR, P.O. Box 51212, Seattle, WA 98115, tel. 206-523-2702 or 800-635-8790). Price is about $5.50 to $6.00. Seed is loaded into the trays at 10,000 per tray with 12 trays per stack, 2.8 million per raft. Seed is cultured using rafts the year around. We used a second type of raft (10 ft. X 14 ft.) with six wooden racks suspended with wooden window screen trays (2 ft. X 3 ft.). Seed is loaded at 15,000 2-3 mm per tray with 8 trays per rack and 720,000 per raft. We used 26 rafts of this type, but plastic trays are better for clam seed. The wooden trays have numerous disadvantages including weight, high maintenance and longevity (5-6 years if maintained frequently). Only advantage of the wooden trays was low cost (Figures 51 and 52). These rafts and racks are now used for oyster and mussel seedlings to 10 mm.

Question : What keeps the trays clean?

The tidal current. We have 3 raft sites and the tidal current varies at each site. We found that the better the current, the better the seed grows. The tidal variation is up to 10.5 ft. and the tidal current is up to 4 knots at the raft anchoring sites. The clams still need cleaning up to once a month in the winter with a portable wash pump.

Question : How about fouling?

That can be a problem. During the winter, it's not much of a problem. During the spring and summer, seed is being handled frequently and put onto dry, clean trays. The fouled trays are left in the sun to dry and then cleaned with a brush and hose before reuse.

(*) Editor's Note : Unless specified, all costs are in US funds for this presentation.

Question : How about substrate in the trays?

No substrate is added to the trays for nursery rearing. The seed is planted directly onto the mesh in tray culture and also onto 1/8" bags for rack nursery culture. Our experience has been that Manilas do okay without substrate up to about 25 mm.

Question : How long does it take to reach 6-8 mm from planting in trays at 2-3 mm?

It depends on the season. It generally takes about 4-6 weeks in the spring through fall, and up to 3 months in winter. We start out at 10,000 per tray and go through the trays 3 or 4 times before the complete group is up to 6-8 mm or 12-15 mm.

Question : How are the wooden trays closed?

Rubber inner tubes are cut into strips and then an "S" hook is tied on each end. The strap is wrapped around the tray at each end--two straps per pair of trays. Aluminum welding rod marine grade 1/8" is good material for the "S" hooks.

Question : How is the window screen attached to the wooden trays?

We use a Senco "J" tool 1/2" "C" staple with a pneumatic gun. A wooden strip is stapled over the window screen after it is attached to the wooden frame. We use a Senco MIT gun with 1.5 inch staples to put together the tray frames.

Question : What is the maintenance required on the wooden trays?

A couple of times a year they need to have the staples checked and when necessary re-stapled. Definitely a high maintenance item and plastic trays are recommended if you are budgeted for the initial start-up expense.

Question : Where do you glue down the mesh?

For window screen, we glue down around the complete edge of the plastic tray and up along the sides. For 1/8" mesh, available from Norplex, we just line the bottom of the tray because 1/4" sieve clam and oyster seed cannot get out of the 3/16" holes on the sides of the green or brown trays (Figure 53).

Question : How about fouling?

The plastic trays are subject to fouling and need to be dried out as often as possible. We handle oyster seed about every 10-14 days in the spring-fall and clam seed every 4-6 weeks. At that time, badly fouled trays are stored in stacks for dry out and dry, clean trays are put into service.

Question : What are the divisions in the middle for in the plastic tray?

Structural strength, but they also keep some of the seed from ending up all in one corner. Clams keep themselves fairly evenly distributed. The rafts have rebar frames that keep the stack vertical to the current, so that helps somewhat in keeping the seed from stacking in one corner.

Question : Is stacking in the corner a big problem?

Not much with clams, but can be with oysters, so the seed should be "worked through" frequently, say every 10-14 days for small oyster seed in the 6-9 mm to 9-14 mm and every 15-30 days for larger seed.

Question : Do you see a lot of mortality?

Not if you are servicing them regularly. Juvenile crab and starfish settlement in the trays has been a nuisance this winter, but the mortality has been very low.

Question : How many people are employed?

Mr. Ted Kuiper and I work during the winter with one part-time person working on trays, building rafts and maintenance. During the spring to fall, Mr. Ted Kuiper employs two full-time and two part-time. Mrs. Linda Kuiper, Ted's wife, handles sales, administration and helps with production. The bay work with the trays requires two full time for 10 plastic tray rafts and 26 wooden tray rafts. We prefer the plastic trays and are shifting away from the wooden trays to plastics for clams.

Question : Is there uniformity of growth in the tray stacks?

It doesn't seem to make much difference with clams. Oysters sometimes do better in the top trays due to greater circulation from wave action.

OTHER NURSERY TECHNIQUES

Bottom Sand Boxes

This technique has been used in Europe and by some of our customers in Washington. An area of bottom is shoveled free of boulders and other debris and beach sand is loaded into a screen lined wooden box with 1/4" screen (Norplex, Inc.) stapled to the top. A few growers have done well with this technique to 10 mm seed. We have not used this technique due to heavy silt loads, heavy crab populations and wave turbulence.

Bottom Bags

These are popular in northern Italy where seed is loaded into 3 m X 1 m bags at 20,000 per square meter (Figure 54). Mesh is nylon, 1180 screen, about the same as our domestic fiberglass window screen but more durable and sunlight resistant (Figures 55 and 56). Bags are staked to the bottom and seed is grown to 6-8 mm for bottom planting in mesh covered beds. Works well in areas of low predator populations, stable bottoms and low conflict with recreational users. Salinity at these sites was 12 to 26 parts per thousand and temperature 4 to 26 degrees C. Heavy sea lettuce growth requires frequent cleaning in the summer.

Developed by Mr. Paolo Breber in Italy. Photos courtesy of Mr. Breber.

Rack And Bag

Developed by Dr. Randy Shuman at Willipa Bay after the French system. 5,000 6-8 mm seed is planted into each 1/8" bag (Figures 57 and 58) with two 10 inch by 18 inch bags inserted into a 1/4" bag (for support) and then 4 bags are attached to each rebar rack. Seed is grown to 15 mm to plant into bottom bags containing substrate. Mr. Peter Steenbergen and Mr. Deg Whittall used a similar nursery system for 2-3 mm in window screen wooden trays on rebar racks on Lasqueti Island. Then 6-8 mm was bottom planted (Figures 59-61) under protective netting, or planted into wooden trays with 1/8" netting for nursery rearing to 15 mm for bottom planting.

Other Types Not Pictured

Another type that Mr. Ted Kuiper has liked for small scale is hanging from rafts or long lines window screen bags (1.5 ft X 2 ft.) with a wooden (1" X 3") fir spreader in the bottom of the bag. Worked quite well in high current areas from 2-3 mm to 6-8 mm. This technique was developed by Mr. John Sprague and Mr. Scott Hunt. A large Humboldt Bay company is planting 2-3 mm seed into burlap bags containing about 10 pounds of gravel and then inserting the burlap bag inside a Ralph Schley growout bag (Norplex Inc., tel. 206-251-6050) which are about $1.75 each (Figure 62). The bags are planted on firm bottom at the rate of 1/2 million seed per tide loading at 1000 per bag. Seed is not handled again until harvest at 35 mm+. Other techniques that are used include sand filled boxes suspended from racks or rafts. Mr. Dick Poole will cover raceway nurseries.

GROW OUT

I will briefly comment on grow out, to cover some aspects that may not be mentioned by other speakers. We do not have a grow out, so I speak from experiences related by our customers.

Those growers that have been most successful in Washington have used the nursery seed as enhancement for an existing commercial population. Some growers have reported increasing their commercial harvest from 10,000 pounds per acre to as high as 40,000 pounds per acre with seeding. The "enhancement" growers have an advantage with ground that is already in commercial production by generally having low predation and ground that does not shift with winter storms. Some of the "enhancement" growers are placing netting over the ground to cut down on bird predation. These growers generally do not have significant problems with fish, crabs or moon snails. These growers plant at the rate of 250-500 6-8 mm per square yard depending on the level of natural settlement. The other type of grower, I will call the "new ground grower", may have some natural population, but the ground is not considered at a commercial level. These growers may face severe problems from predation by moon snails even if they net their ground carefully. According to Mr. Don Rogers, who will publish a paper soon on moon snail predation, the juveniles recruit onto the flats from adjacent deep water and penetrate

quite easily through the 1/2" protective netting and can consume a clam that is 1.25 times the size of the snail. To overcome this problem, he has developed a bag at about $2.75 (Figure 63) that is loaded with 12-15 mm seed for grow out. This bag has 1/4" mesh and is bent to form a box. A shallow depression is dug in the bottom and the bag is laid on the bottom and allowed to fill in with small gravel and sand after a few tides. The 12-15 mm seed is then inserted at 300-500 per bag.

Another growout method using bags is to use oyster shell and gravel mix in the Schley bag and then broadcast 4-6 mm seed into the bag after the bag is planted onto the bottom. The seed attaches to the gravel and shell with low losses due to "fall through" or migration out of the bag. This technique does have difficulty with juvenile crabs growing inside the bag. Several thousand of these bags are in production at Willipa Bay.

Question : Does the clam bag have a flimsy side?

No, it is a rigid 1/4" bag that runs about $2.75 each for a 3 ft. bag. Sorry, I did not bring one along.

Question : Can you nursery in this bag?

Yes. Some growers do plant small seed (2-3 mm or 4-6 mm) into the bag after the bag in on the bottom with substrate inside. Mr. Bob Toebbe (tel. 206-866-0620) has developed this technique. This bag can also be used on racks with a 1/8" bag insert containing 6-8 mm seed for growout to 12-15 mm for bag or bottom grow out.

Question : Could you please describe the nursery on racks?

There are three ways I am familiar with: 1) wooden trays on rebar racks either for 2-3 mm seed on window screen or 6-8 mm seed on 1/8" (Norplex) mesh; 2) 1/8" bags with 6-8 mm seed loaded at 5,000 per 18" bag - 2 bags inserted inside a 1/4" bag for support for rearing to 12-15 mm; and 3) plastic trays on racks with window screen inserts. We have not had much luck keeping the plastic trays on racks due to our local high current and wave action, although racks could be built to hold trays securely. Mr. Bill Callahan (tel. 415-663-8609) has developed a system for plastic trays on racks.

Mr. Scott Sterner (North Bay Shellfish, 891 Eucalyptus, McKinleyville, CA 95521, tel. 707-839-4723) has also been clever in his approach to predation. He is using our single Pacific seed and planting the Pacifics and 12-15 mm Manilas as a mix in a tubular netting (Figure 64) for growout off bottom using 50 foot long lines. He plants about 75-125 long lines per tide using 1" PVC pipe as support every 6-8 feet. The oysters are harvested within one year and the clams are planted a second time at 25 mm+ for growout the second season. He has some predation from crabs reaching his netting, but in general quite low.

Although we prefer gravel for growout on our coast and in some cases, very experienced growers have failed in sand growing areas, most European growers are successfully growing in sand. Ms. Penny Dravers,

(Guernsey Sea Farms, Parc Lane, Vale, Guernsey, Channel Island, England. Telex 4191445 Chacom G Oyster) has authored a very good manual on Manila clam seeding in Europe and site selection. When investigating a site, you should take the time to do some bottom sampling with a quadrat sampler (Figure 65) that you push into the bottom, then remove everything inside the square, sieve, and then count the number per square meter (Figure 66). Regular sampling will give you an idea of growth rate, natural Manila clam settlement and predator settlement. Mr. Dan Cheney (tel. 206-644-2708) and Mr. Peter Becker (tel. 804-588-5707) have developed some successful ground management strategies based on regular quadrat sampling. Anderson (1982) in Wash. Sea Grant Technical Report WSG-82-4 has a complete description of bottom sampling and standing crop estimation.

Question : Do you have a handle on mortality rates?

For the nursery, mortality is very low once the seed reaches 2-3 mm. From 2-3 mm to 10-15 mm in most grower's nurseries, the mortality is very low. In grow out, the mortality has been reported to be very low using bags but the investment in bags is costly for the first crop. Grow out on bottom for the "new ground grower" can be very high, depending on local predator level. There are several Sea Grant reports out from Washington, mostly from Dr. Ken Chew's students and associates at the University of Washington. They report a wide variation in mortality from 5% to 95% more or less. At Lasqueti Island Mr. Peter Steenbergen and Mr. Deg Whittall planted 500 6-8 mm per square meter and reported sampling 244 per square meter two years later. Mr. Ted Kuiper mentioned seeing heavy losses to crows in the first week picking the seed through the netting.

Question : What size do most growers use for bottom planting?

Most prefer 6-8 mm ($5.59 per 1000), but last year some began experimenting with 4-6 mm ($4.50 per 1000) with varied results. There has been no consensus yet on what is the best size for bags, all sizes are being used from 2-3 mm and 4-6 mm that are broadcasted into the bags after the bag is well seated to the bottom, and 12-15 mm that are planted into a bottom bag and are big enough not to escape out of the mesh. For bags, Mr. Ted Kuiper believes there are between 10,000 and 20,000 bags in production from Washington to California, and we have heard of no real busts on bags yet.

In Italy, grow out with and without netting on sand bottoms is the most common. Also, they have been very successful in growing Manilas in sand bottomed ancient fish ponds to market in less than two years. Temperatures vary from 4 to 34 degrees C. Water exchange is about 20% per day. Mr. Paolo Breber is about to publish a paper which attributes the most productive sites to the abundance of pennate diatoms.

Question : What are your temperatures?

Temperature varies from 4 to 24 degrees C. Setting temperature we use for clam larvae is 24-26 degrees C.

PLATE 2

Figure 45: Kuiper Mariculture Inc. 6-8 mm Manila clam seed.

Figure 46: Kuiper Mariculture Inc. 2-3 mm Manila clam seed.

Figure 47: Kuiper Mariculture Inc. 4-6 mm Manila clam seed.

Figure 48: Upwells at Humboldt Bay, California.

Figure 49: Plastic tray with window screen glued insert.

Figure 50: Plastic tray raft at Humboldt Bay, California. Raft measures 12' x 20' with 24 tray stack wells.

PLATE 2

Figure 45

Figure 46

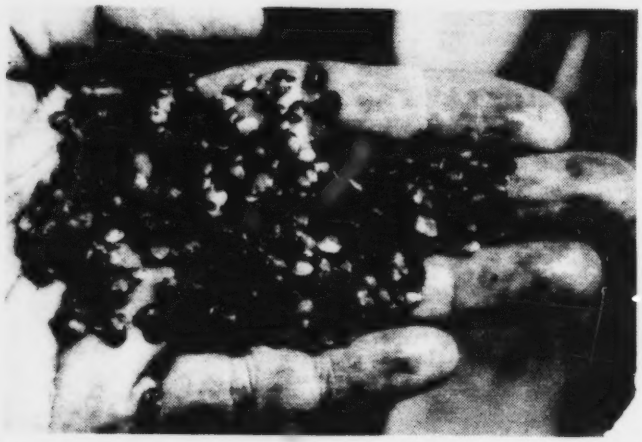


Figure 47

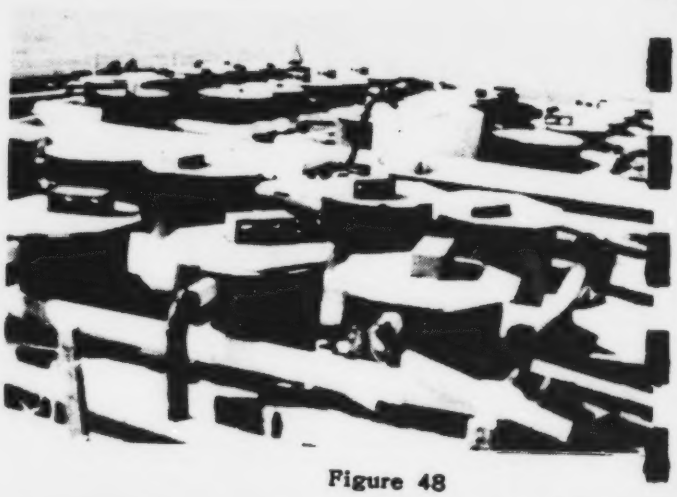


Figure 48

Figure 49

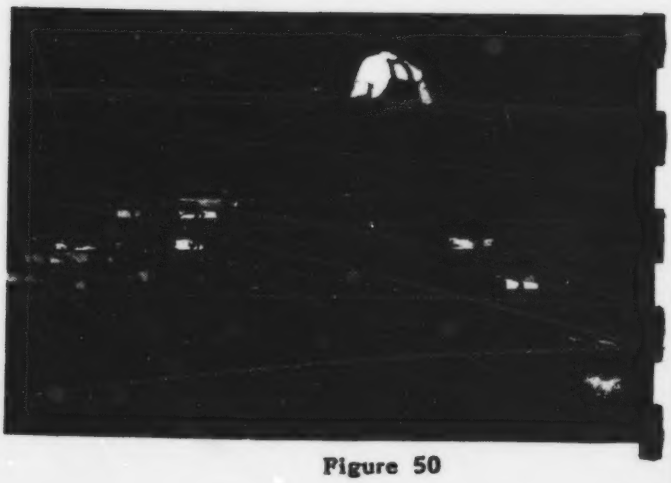


Figure 50

PLATE 3

Figure 51: Seed in a wooden tray used for nursery rearing from 2-3 mm to 6-8 mm.

Figure 52: Racks of wooden trays and wooden raft in construction.

Figure 53: Glueing 1/8" tray inserts with a TG-4C glue gun.

Figure 54: Staking down a 3 m x 1 m nursery bag to the bottom in Italy.

Figure 55: Breber staking bag.

Figure 56: Harvesting seed from Breber bag at 6-8 mm for bottom planting under netting.

PLATE 3

Figure 51

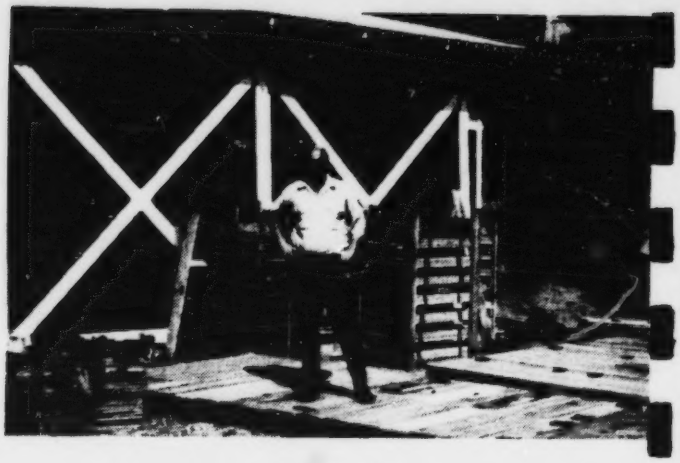


Figure 52

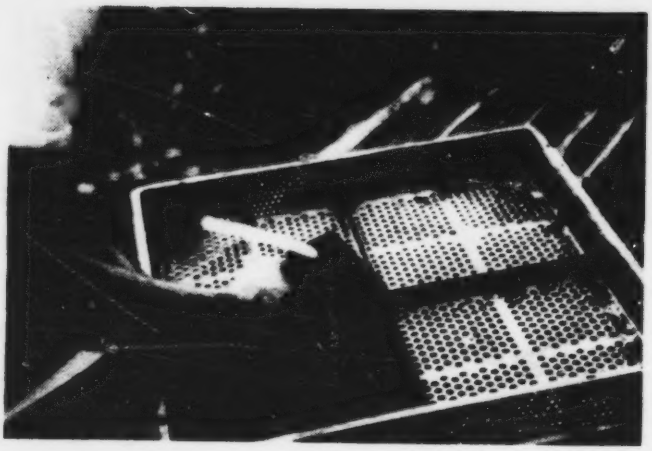


Figure 53

Figure 54

Figure 55

Figure 56

PLATE 4

Figure 57: Norplex 1/8" bag used for nursery of seed from 6-8 mm to 12-15 mm. Bag is inserted into a 1/4" bag for support and then strapped to a rebar rack in the intertidal.

Figure 58: 6-8 mm seed inside a Norplex 1/8" bag.

Figure 59: Rebar racks with wooden nursery trays at Lennies Lagoon, Lasqueti Island.

Figure 60: Protective 1/2" Conwed netting on beach at Lennies Lagoon, Lasqueti Island.

Figure 61: Mr. Steenbergen and Mr. Whittall planting 6-8 mm seed under netting on the incoming tide at a density of 500 per square m at Lennies Lagoon, Lasqueti Island.

Figure 62: Mr. Ralph Schley's clam bag (3' x 2' with 1/4" mesh) from Norplex for bottom planting. Cut pipe on end used for closure.

PLATE 4

Figure 57

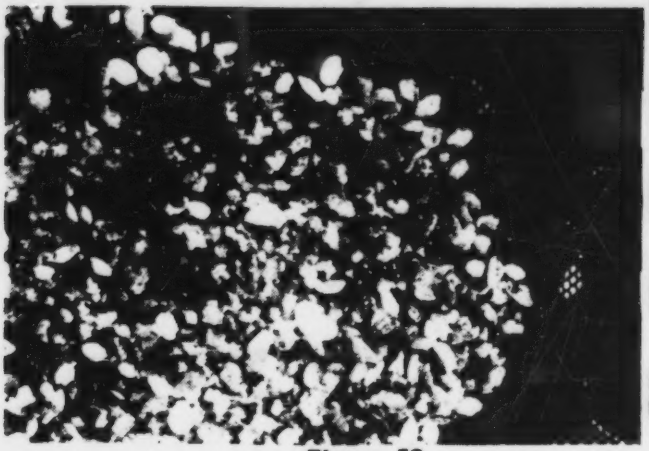


Figure 58

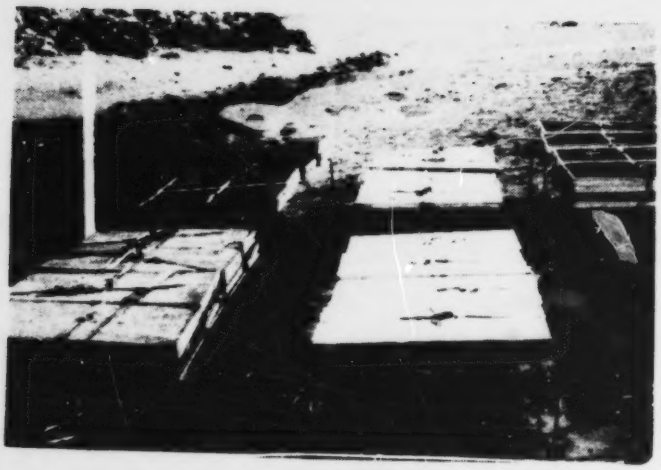


Figure 59

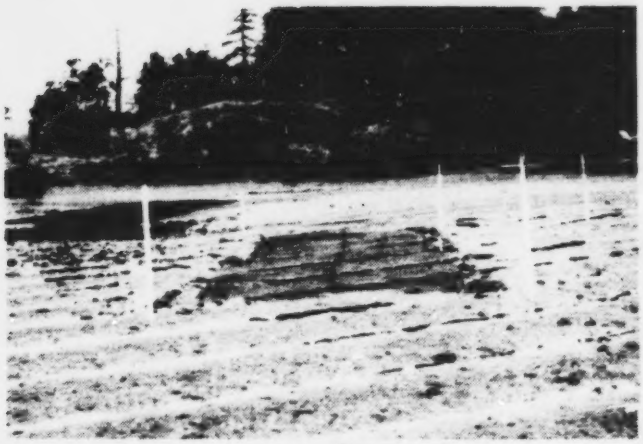


Figure 60

Figure 61

Figure 62

PLATE 5

Figure 63: Mr. Don Roger's clam bag, from Norplex, bent to form a box used for bottom grow out.

Figure 64: Sterner grow out netting. Tubular, hung in 50' long lines supported by PVC pipe every 6-8'. Clams planted with single oyster seed in netting.

Figure 65: Quadrat sampler with sieving screen used to estimate standing crop.

Figure 66: Lasqueti Island quadrat sample, showing size range and numbers before planting.

PLATE 5

Figure 63

Figure 64

Figure 65

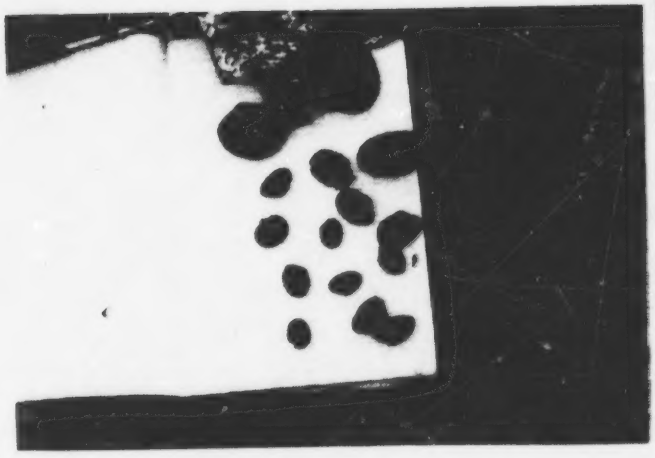


Figure 66

HATCHERY PRODUCTION OF CLAM LARVAE AND SEED

Mr. Dick Poole, Lummi Indian Band

Early efforts in culturing shellfish under hatchery conditions began on the east coast. The technology was based on the ability to bloom natural algae and rear oyster and clam larvae in the bloomed water. Due to problems associated with this system, research on suitable algal species for larval culture was conducted by Dr. Loosanoff and others. Some of the culture systems used both the "bloomed" water and algal species cultured under bacteria free conditions.

In 1965, I advised Mr. Bill Budge that technology for the culture of oyster larvae existed and oyster hatcheries could displace the 100,000 cases of seed imported each year from Japan at a cost of several million dollars. Pacific Mariculture was established and was the pioneer for hatcheries on the Pacific coast.

In 1969, I was hired by Lummi Aquaculture to begin an oyster hatchery project in Puget Sound using available technology. My associate, Mr. Al Casimir and I started that project on Lummi Island, Washington (Figure 67). The initial Lummi hatchery concept used "bloomed" water with supplemental algal cultures. Larval culture tanks were 4 feet in diameter by 3 feet deep with a volume of 1,000 liters. Based on tests in the lab, it was projected that 10 larvae per milliliter could be reared. Using this technology, the 11,000 square foot hatchery began operation in 1973. The Lummi Shellfish Project has now been in operation 19 years (Figure 68).

During the first year of commercial operation, it became obvious the scenario on which the hatchery was built would not work. Bloomed water was not reliable in Washington and the projected density of 10 larvae per milliliter produced disease and unreliable results. Reduction of larval densities and use of bacteria free algal cultures produced more reliable results.

The larval tanks were obviously too small and the abandonment of the large bloom tanks, 14 feet by 4 feet with 16,000 liter capacity, provided opportunity to try larger culture vessels. Stocking densities were reduced to one larva per milliliter or less with excellent results. Today, hatcheries use tanks in excess of 80,000 liters for the basic hatchery unit. Total liter volume in the Lummi Hatchery is 450,000. Algal capacity is slightly over 100,000 liters to support that volume. At present, 48,000 liters is devoted to clam culture. Hatchery capacity is based on a large volume to provide a reliable output.

In 1988, the shellfish operation spawned Manila clams (Venerupis japonica) on a regular basis. Spawning started April 29, 1988, and the first pediveliger larvae was available May 11. That spawning produced more than 150 million clam larvae for sale.

Tanks were stocked at a density of 8 larvae per milliliter and fed Isochrysis sp. (T. Iso) daily at a rate of 50,000 cells per milliliter. As the larvae grew, the feeding rate was increased to 100,000 cells per

milliliter. Daily counts of algal cultures were made using a hemocytomer to determine the amount of algae culture to be added. Additional algal foods including 3H (Thalassiosira pseudonana), Chg (Chaetoceros muelleri) and VA12 (Pseudoisochrysis paradoxa) were also used.

Brood stock for the larval cultures was taken from the Lummi Aquaculture pond and conditioned at 20-24 degrees C. As spawning was noted, the spawning clam was removed to an individual pyrex glass dish for additional control. On several occasions in the static conditioning system, spawning occurred overnight or with such rapidity that it was impossible to separate the animals. Fertilized eggs removed from this system produced mixed success. Polyspermy lowered survival to zero in most cases.

Fertilized eggs were placed in tanks, 8 feet by 6 feet deep with a volume of 8,000 liters. Air was bubbled continuously into the system from a high volume low pressure carbon vane blower. Lack of air pressure prevented aeration from being started at the bottom of the tank. The glass aeration rod was 3-4 feet below the surface. No air stone was used. Tanks were changed every three days with larvae being caught on an appropriate size screen. After three days, the fertilized eggs had developed to straight hinge and early umbo size larvae. They were caught on a 50 micron screen and sorted on a 74 micron screen. The larvae generally grew fast enough to throw away all the larvae passing the 74 micron screen. Larvae were counted and returned immediately to the cleaned tank with fresh saltwater at 22-24 degrees C and food was added.

Larvae grew very rapidly and additional algal species were added to the diet when they reached 120 microns. These included 3H (Thalassiosira pseudonana), VA12 (Pseudoisochrysis paradoxa), Chg (Chaetoceros muelleri) and CC (Chaetoceros calcitrans).

At the end of 9-12 days, the larvae had reached 160 microns and some had developed a foot. At this time, the water was changed daily to separate the pediveligers for sale to growers or planting in the Lummi culture systems. Larval densities had been reduced so that 20-25 million larvae were in each tank (3-4 per milliliter). Selection of the fastest growing larvae at each change produces the fastest growing cultures.

As the pediveligers sink and become crowded on the bottom, they are very susceptible to bacterial contamination and can be reduced to shells in 24 hours. Sorting the larvae on the 120 micron screen and placing the post set larvae in either an upwell or downwell system separates the metamorphosing larvae and reduces the risk of contamination. The use of substrate is not necessary, however, larvae will not pass through a downwell system with 120 micron screening with substrate as easily as a screen without substrate. Sizing the substrate so that a small amount of growth will allow separation of clams from the substrate allows counting, cleaning and transfer of pure clams at a later date.

The larvae are 160-210 microns and the shell appears soft and allows the pediveligers and small clams to sometimes slip through a screen system, especially when high pressure differentials are present.

The pediveliger clams are shipped in the same manner as eyed larvae however, it appears they are not as hardy as oyster larvae. This has not been confirmed except through personal communication with buyers. In other words, expediting the transfer of post set clams appears to provide the best returns.

A grower would receive larvae collected from the tank on a 105 micron screen and sorted on 120 or 130 micron mesh sorting screen after cleaning with a larger screen, generally 180 micron, through which the larvae would pass. The counted, sorted larvae are collected on a clean cotton square which has been dampened with seawater. A label is attached to the package with the date and number of larvae. The clams are placed in the refrigerator in a styrofoam box to reduce temperature impacts and held at 40-50 degrees Fahrenheit until shipment. Larvae are generally shipped immediately to growers who have made commitments for the larvae in advance. Excess clams are used in Lummi culture systems.

In 1989, the Lummi Shellfish operation can provide 200 million pediveliger Manila clams per month from April to September. Additional larvae could be reared by devoting additional hatchery space to the culture of clam larvae.

Question : Could you please describe grow out systems used by the Lummi operation?

We have planted most of the pediveligers in a grow out system. We had one very large grow out system that we used this year which was a salmon raceway 80 feet long, 16 feet wide and 3 feet deep. Adjacent to the raceways are 2, 40 foot circulars which we also had available. We took the raceway and put in the bottom of it 3/4 inch black polyethylene pipes a foot apart with holes bored a foot apart. We put pea gravel level with the tops of the 3/4 inch pipes, put felt over the top of the pipes and on top of that gravel. The felt was the type they use to stop weeds in your garden in rolls 3'x 50'. One variety has holes about 500 or 600 microns and another type is a mat-like material. The material that we used was like a matting and then we put pea gravel on the top of that and a little bit of # 20 sand and in the 80 x 16 foot raceway, we planted the 200 million clams on the 4th of July. We had an upwelling from the bottom through the network of plastic pipes and then we also provided a flow across the top. In the adjacent circular pond, we bloomed the pond water by adding 3 or 4 pounds of 55-0-0 and filled the ponds with seawater. We let them sit there for about 3 days with an aeration system and then started at that time with submersible pump to pump the bloomed water into the raceway. We got excellent blooms with this system and in order to maintain control when the thing looked like it was starting to get erratic, we would stop it and start the other pond. Clams are still in the grow out system at this time, a lot of them are over 1,000 microns with some as small as 400 microns. The size variation maybe due to circulation, some of the area has good circulation and where the circulation was good, the clams are larger. Where it wasn't circulating as well, the clams are smaller. We won't know what we have in that system until we take it out and sort through it. My estimate is that there are still about 20 million plus in the system of approximately 320 square feet.

Question : The Lummi Indian operation had federal funding and was not viable, why not? Were the Indians not able to carry the project even with federal funds?

Well that situation has plagued and I truly mean that, plagued the operation. We started in 1969 with the Indian project and of course, we had a pretty free flow of federal funds. By 1973, we were producing a tremendous amount of oyster seed. We produced nearly 10,000 cases of seed each year for the period of 1973, 1974 and 1975. The intent was to sell seed but we could hardly sell any, so we planted it on our grounds. The growers had the same feeling that it was unfair competition, and that the costs didn't represent true costs so about all the Indians could do was plant the seed on their ground. This year the operation using those facilities stood on its own, and provided enough revenues to make the operation go. It provided enough output from the hatchery to pay the hatchery personnel and had enough shellstock on the ground to pay for that. It has taken 20 years.

Question : Is the culture of clams in trays possible?

The Nestier trays used by Mr. Ted Kuiper had 50 million cultchless oysters which were put in those trays. We had a lot of trouble with them. We glued the screen in just as Mr. Ted Kuiper is doing for the clams. Once you set that tray down, all you have is the holes around the sides, the trays work and everything tips and goes to the corner. In the case of clams, you have less mortality than you do with oysters if you don't go through those things as Mr. Ted Kuiper does every week, you are going to have a lot of mortality so it becomes a very intensive kind of a situation and requires very good management.

Question : What is the mortality rate of seed clams?

I figure around 90%. We started with 200 million and we have about 20 million left.

Question : What was the cause of mortality?

Some of those might have washed out but we had a screen at the outlet and the first day we had to throw about 50 million of them back into the raceway and the next day there were 15-20 million that we threw back and the third day a couple of million and the fourth day they had pretty well settled down.

Question : Is the bloom system reliable?

That is the problem with the bloom system. There is no control on what is happening and we all know what Washington weather is like, we can have months of clouds. On the east coast, they have a lot more sunshine and their control is a lot better. There were two ways it was done on the east coast. It was run through a centrifuge and that allows all the particles over a certain density to be taken out and just the lighter density material to go into the bloom system and the other way is to run it through a bag and take everything out less than 20 microns and bloom that.

Question : What is the price of pediveliger clam larvae?

A $100.00 US per million.

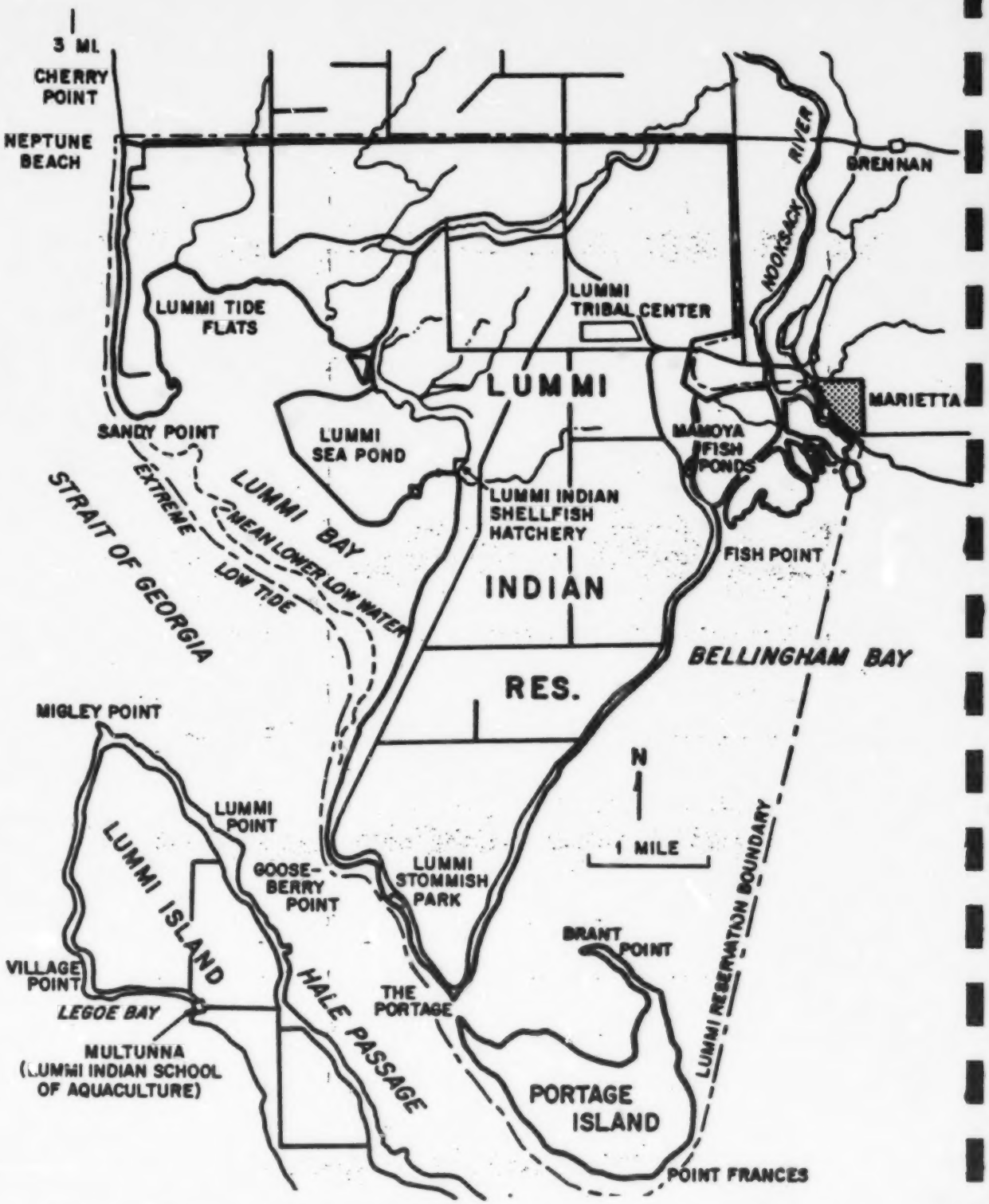


Figure 67: Map of Lummi Indian Reservation showing boundaries and surrounding lands and waters. Aquaculture facilities are denoted at their locations.

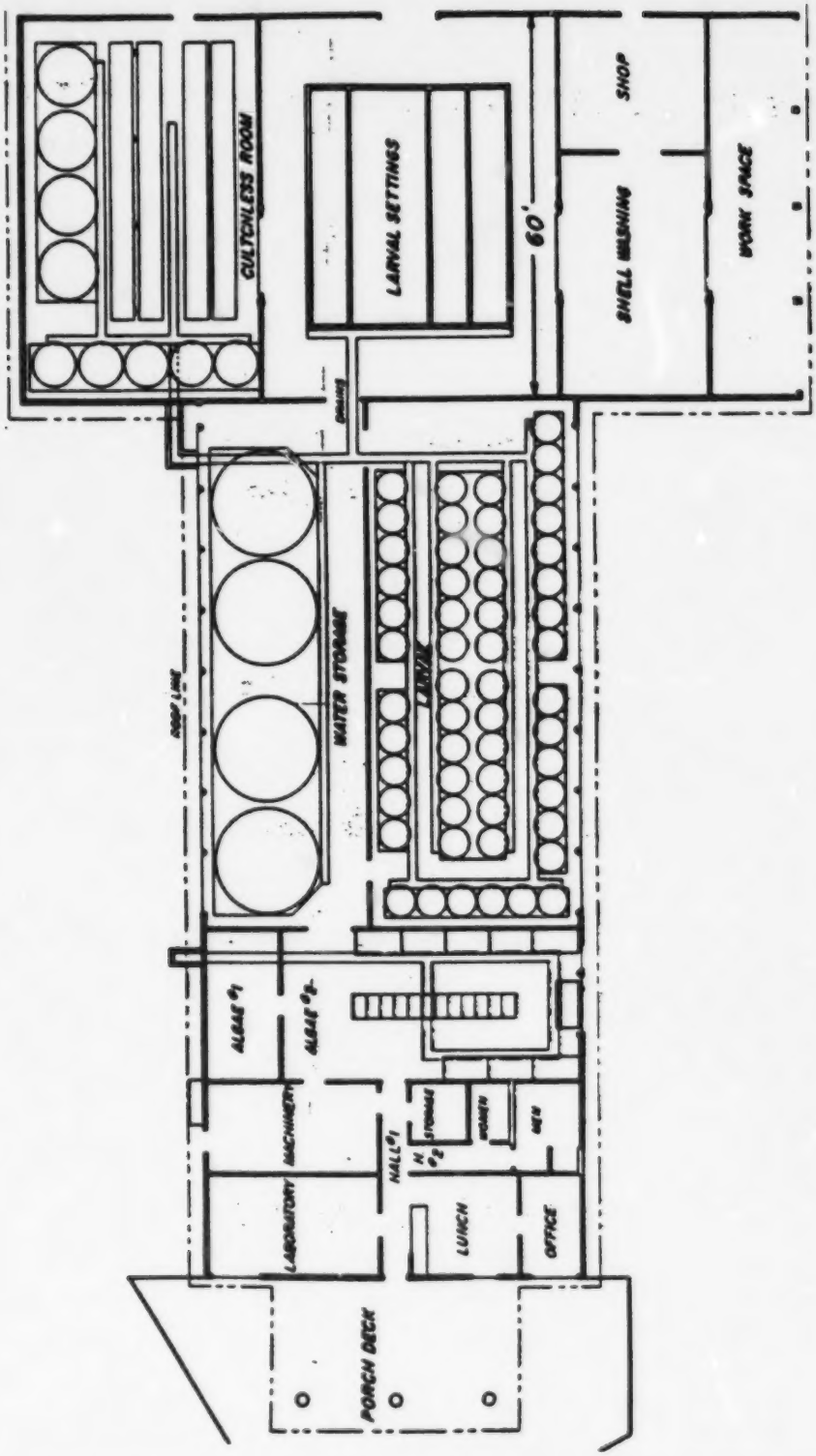


Figure 68: Layout of Lummi Indian shellfish hatchery designed by Mr. Richard Poole (Lummi Shellfisheries Director).

CULTURING CLAM SPECIES, THE WASHINGTON EXPERIENCE

Mr. Dick Poole, Lummi Indian Band

Let's look at some potential grow out situations for clam culture here and some of the systems that might be used.

Figure 69 is a common type of upwelling system that is used in a number of locations. You can make this system a downwell by adding a water source above the tanks. Water comes from a pump to a head tank and to a series of filter bags. Water flow goes in the bottom inlet through the screen which holds the shellfish. The water amount coming out is adjusted by tipping or moving the elbow on the side of the tank shown as the adjustable outlet flow control. You can, of course, reverse the flow by putting water in the top and taking it out through a standpipe in the bottom. These kinds of systems can grow clams in an upwelling situation a foot or two thick. The outside tank is 3 feet by 3 feet and the inside tank is 30 inches in diameter. The screen is fixed to the inside tank with epoxy. This screen must be very tight to provide the proper flow and support. There are a lot of variations to this system but this is essentially the way it operates.

Another variation would be a set of trays in a trough (Figure 70). The trays seal against the trough sides and bottom. The water flows up the screen in the rearing area and down through the outlet screen to catch anything that may overflow as a safety. You could reverse the flow in the trough and make it come back down the other way and make it a downwell situation. The original Lummi hatchery had trays 32 feet long stacked 3 high to produce cultchless oysters. You need to add the overhead water inlet above the trays to add water. If you don't have the make up water all the way down the overhead line, the food is all gone very quickly. I have seen upwell systems in plexiglass tubes that have clams in the bottom 8-10 inches deep. Food is upwelled through the bottom with the seawater and you can see the food color coming up through the tube to the screen supporting the clams, by the time it gets through the clams, it is clear. They take everything out.

The screen size in an upwell/downwell system for clams, pediveligers, post set larvae (170-200 microns in size) would be 120 microns and if you were using it for set oysters, 210 microns.

Figure 71 is a floating type of system. Some floating systems have solid bottoms with screens on the ends. The raft shown has a fiberglass grate bottom with a smaller mesh screen across the top of the grate. You can add an aeration lift device or a pump to put water in from the top and make it a downwell or you can put the raft into a tidal flowing situation and allow water to flow by the raft. The raft can be moored with two anchors or you can let it swing around on one anchor. If the current is very strong and flowing against the tidal diversion structure as shown in Figure 71, as the flow increases, the board is going to go up against the bottom of the raft and seal the bottom off to prevent the current from blowing everything out of the raft. The flow in controlled by a series of holes in the bottom as shown. A similar system was used in Willapa Bay many years ago with good success.

I am not going to go through rearing the shellfish up in all of the systems because I think it has been pretty well covered.

Hatchery conditions allow brood stock to be spawned in January and reared in the hatchery. Available hatchery seed from these early sets should be placed in the trays early and planted on the ground as early as possible. Some of the clam stock coming directly out of the hatchery can be planted on the ground. The hatchery system gives you some flexibility as to how you can plant, time and so on. You don't want everything ready right at the same time and being able to have some flexibility really helps. I have thought a lot about gravel surface preparation, netting and natural conditions and so on. The screen does provide you maximum protection but I think manipulation of that surface preparation might give you as good of a situation as placing the net. I think a lot of you perhaps envision rock as something that ties together and provides a more binding surface similar to a net and is more difficult for crabs to dig through the angular rock. Round rocks can be shoved aside and little crabs go right through. If you have ever dug through crushed rock, you note crushed rock binds up very tightly. On beaches that have good clam population, often times you have an over net of larger rock so that the rock over net serves as a defense against some of the predators. Surface preparation with crushed rock can accomplish the same thing as a net. Oysters are a good net across the top however, they may silt in the clams or harbor crabs and worms.

Question : What about shell for clam beds?

In some cases, people have ground up shells and put on beds to harden the beds. In the south Puget Sound ground shell provided an excellent setting media for Manila clams. Ground shell is not always available. That is the tough part.

Question : What is the best situation for planting pediveliger seed clams?

Let's do some hypothetical creation here of a situation that we would like to see as clam culturists and let's think of some of the things that we know. Through our hatchery experience we know that we can grow clams under very thick conditions using upwellers, downwellers, and we know that in the hatchery, we can get very good survival and very good growth. We know also that with improper handling and so on that we can get some serious disease problems. We know that predator situations in the hatchery are just about nonexistent. We solved wind and wave problems. So what we would be looking for in the field would be an ideal hatchery situation. Well dream on, but perhaps you can minimize some of the risk that you are going to take in the field by looking at the situation. Let's look at ground preparation.

I think is some instances the ground preparation situation is minimized. I come from a background of farmers. You prepare the ground, you take everything off of it, fertilize, and you plant the seed to create the best probable success. You don't leave any worms sticking in there, predators, or weeds or what have you. The question was asked about putting the pediveliger larvae out on the flat. One of the problems is

making them happy. Keeping them from drying out. What would a farmer do if he were faced with that situation. He would go get a sprinkler, irrigation system and put up a great big sprinkler. You have seen these huge sprinkler systems that irrigate 40 acres at a crack with the sprinkler going around and around. I believe that at low tide drying is a serious threat to survival of juvenile shellfish. I tried an experiment with oyster seed in that respect. I shaded one batch of bags, sprinkled a batch of bags and left a batch of bags open. The survival of the seed on the bags that were shaded and the bags that were sprinkled was essentially the same. The top bags on the exposed seed showed 100% mortality, so keeping the exposure down, I think, is very important. I think what the point is the farmer needs some kind of innovation. We think that we are at a point where we know everything, but I have gone through this for 20 years and we still have a lot of things that we don't know. I think caution and putting the things together that you know about on an innovative basis is very important. What is of interest, I think, is the nursery systems that are developed to handle clams and oysters in the States. I am sure they have applicability to the Manila clam culture situation in British Columbia.

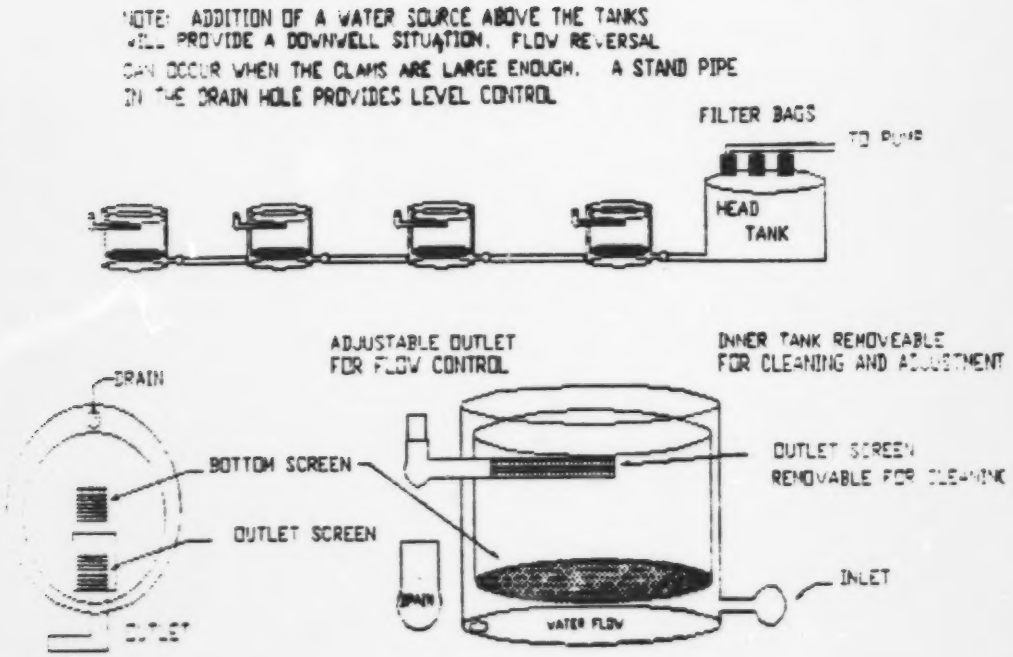


Figure 69: Upwelling system used for geoduck, Manila clams and single oysters. Tanks are 3' x 3'.

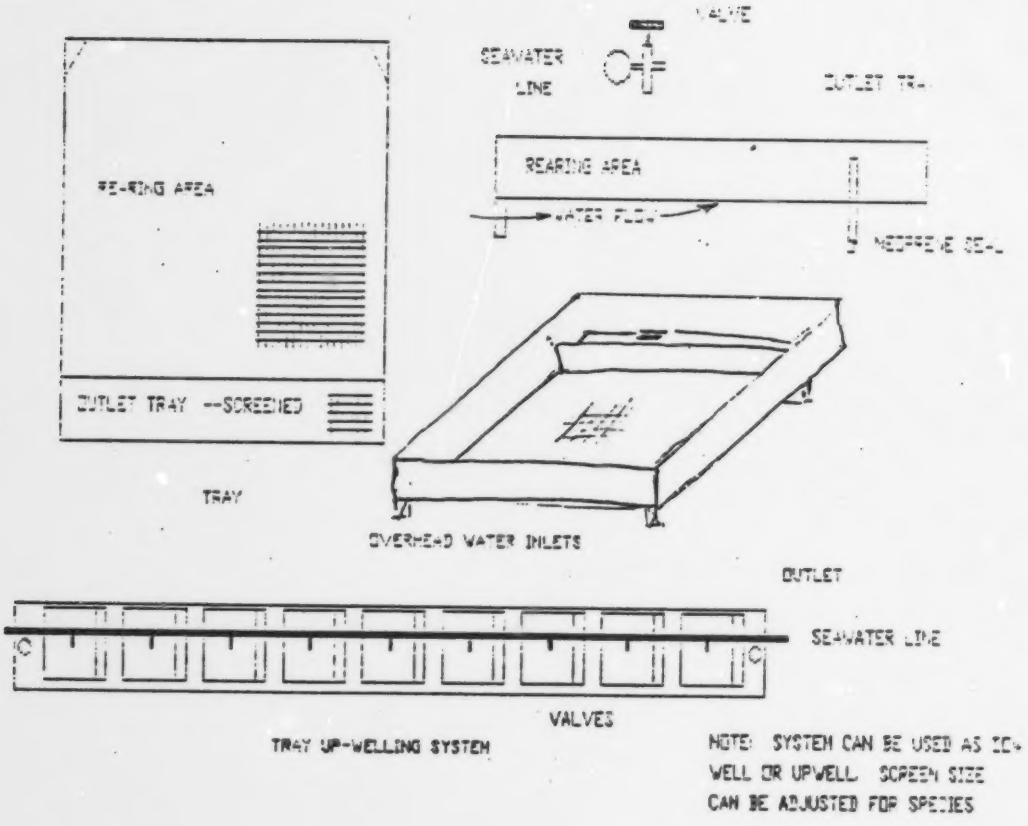


Figure 70: Tray upwelling system used at Lummi oyster hatchery. Trays are 2' x 2' and 4" deep.

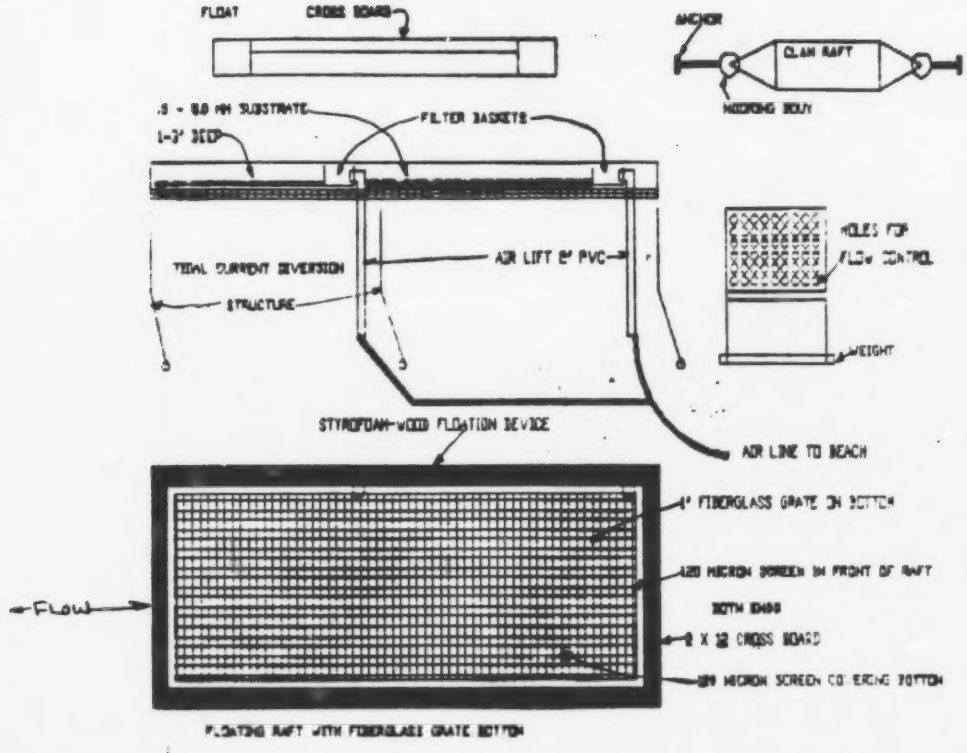


Figure 71: Floating culture system for juvenile clams and oysters.

GEODUCK CULTURE, THE WASHINGTON EXPERIENCE

Dr. Hal Beattie, Point Whitney Shellfish Laboratory

This paper will discuss two items: the geoduck hatchery at Point Whitney; and the potential for geoduck as an aquaculture product.

CO-MANAGEMENT

The geoduck resource in Washington State is managed jointly by two state agencies: the Department of Natural Resources (D.N.R.), and the Department of Fisheries (W.D.F.). D.N.R. denotes tracts within harvestable beds of geoducks, determines minimum bid values for these tracts, sells these tracts at auction and monitors harvest levels. Income from these sales are used directly for D.N.R. management costs, W.D.F. hatchery, management and patrol costs. W.D.F. conducts underwater surveys to determine the amount and quality of standing crops of geoducks, to evaluate harvest efficiency and to estimate recruitment. W.D.F. operates the geoduck hatchery, conducts the planting and evaluation of planting success and enforces fisheries regulations.

HISTORY

The geoduck industry was born in 1970. Extensive surveys conducted by Ms. Lynn Goodwin and the W.D.F. dive team revealed a large resource of subtidal geoducks throughout Puget Sound and Hood Canal. Legislation allowing subtidal harvest of geoduck by divers using water pressure excavation opened the doors for commercial exploitation of geoducks. Five years after commercial harvest began, surveys by W.D.F. revealed a severe lack of recruitment into harvested areas. By 1983, W.D.F. initiated a program to develop a shellfish hatchery for the production of geoduck seed to restock harvested subtidal areas.

HATCHERY AND NURSERY

The pilot hatchery was developed at the Point Whitney Shellfish Laboratory, on Hood Canal. The existing hatchery occupies the office building, parking garage, a converted office in the laboratory and outside areas for larval, algal, and nursery space.

We obtain broodstock from commercial geoduck harvest companies. At the hatchery we separate the geoducks by sex. The sexing process consists of inserting a long needle hypodermic syringe into the gonad mass (through the pedal aperture) and withdrawing a sample. Microscopic evaluation of this sample reveals the sex of the animal by the presence of either eggs or sperm. To improve fecundity, we condition the broodstock for three weeks by holding them in tanks of flowing sea water (9-11 degrees C), and continuously feeding them microalgae. We then induce the geoducks to spawn by increasing the algal density and increasing the temperature to 14-15 degrees C. We capture the eggs on 20 micron screen and wash them with 14-15 degrees C sea water. We add

concentrated sperm to the washed eggs and monitor fertilization and zygote development through microscopic evaluation. After spawning the geoducks, we return them to the geoduck companies. We pay the wholesale rate for the difference in weight between what we took and what we return.

The hatchery process for geoducks is very similar to that for other bivalves. We employ a static rearing system, transferring larvae to newly filled tanks every three days. We rear the larvae at 17-18 degrees C, at concentrations between 0.5 and 1 larva per ml, and feed them combinations of cultured microalgae. The species of algae we are currently using are Taihitian Isochrysis, Chaetoceros calcitrans, Chaetoceros gracilis, Dunelliela, and Chromonas salina. After 21 to 25 days the geoduck larvae metamorphose. At this point they attach to the tank bottom and sides with byssal threads. Using a gentle spray of seawater, we hose the newly metamorphosed juveniles off of the tank surfaces, collect them on Nytex screens, and transfer them to our nursery facility.

The use of upwells for a geoduck nursery proved to be largely unsuccessful. Our nursery, designed by former manager Mr. Ron Zebal, consists of 8 raceways, 12 by 20 feet each. The nursery medium substrate is sand with support media of pea gravel and Typar, a non-woven polyester fabric (Figure 72). Sea water flows into the nursery in two ways. An interstitial flow comes in through perforated 2" PVC pipe laid in the bottom of the raceway; this water percolates up through the gravel, through the Typar and through the sand. A surface flow comes in through a 10" PVC distributor at one end of the raceway. All water drains out through a collector at the opposite end of the raceway. At maximum flow of 15 to 20 liters per second, about 10% of the flow is interstitial, and 90% is surface.

Food for the nursery comes from naturally occurring microalgae which grow in our sea water ponds. The ponds begin blooming in early May and continue through October. We encourage dense blooms in the ponds by adding commercial fertilizer. Each week, we add 480 pounds of 21-0-0 ammonium sulfate and 80 pounds of 0-44-0. In order to encourage diatom growth, we also add 100 pounds of sodium metasilicate per week. The volume of our ponds totals about 21 million liters. Three sewage pumps service the nursery system; delivery equals 8 million liters per day during maximum usage. The water flows into a head box through 150 micron filters. These filters keep out competing larvae and large detritus. The water flows by gravity to the nursery raceways.

To each raceway we add between 10 and 15 million newly metamorphosed juveniles. At a survival rate of 6 to 10%, production from each raceway is about 1 million geoduck seed. The young clams grow to an average 9 mm shell length in about 3 months (Figure 73).

REMOVAL AND PLANTING

In order to remove the geoducks from the raceways for planting we use a fish pump which we borrowed from one of the W.D.F. salmon hatcheries. One person handles the suction hose and literally vacuums up a slurry of

geoducks, sand and water from inside the nursery. This mixture goes through the pump and is delivered to a stainless steel separator screen. The screen catches the geoduck and allows the sand to pass through. Then we transfer the geoduck to upwells for holding and evaluation. It takes about a day to collect, concentrate, and evaluate 1 million seed. The evaluation tells us the volume, average size, and approximate number of seed in each upwell.

Early on the morning of the day after harvest, we prepare for planting. Based on the results of the evaluation, we pack volumes of seed in onion sacks to approximately 5000 seed per sack. We place these sacks in insulated boxes with wet burlap and cold packs, load them into a truck and drive them to a dock near the planting area. After transferring the seed to our boat, we motor out and set buoys to mark the planting site. We plant the seed from the water's surface by boat. The boat is fitted with a planting device which allows even distribution of seed over a 12 meter swath. The seed drifts to the bottom and begin digging in. These small geoducks generally take between 30 and 40 minutes to dig in.

During that time they are very susceptible to predation. In our work, we estimate a 10% survival rate over the first year. After a year of growth, we expect no further losses because by that time, the geoducks are deep enough to be out of the zone of predation.

AQUACULTURE POTENTIAL OF GEODUCKS

The success of any aquaculture product depends upon several factors. Among these are seed availability, market demand, and sufficient market value. The Point Whitney Laboratory has demonstrated hatchery and nursery capability for producing geoduck seed. As demonstrated by the success of geoduck harvesting companies in British Columbia and Washington State, sufficient market demand and product value exist for geoducks.

At the present time Dr. Randy Shuman of Shoalwater Bay Oyster Company is conducting experiments on intertidal culture of geoduck under a grant from the National Coastal Resources Research and Development Institute. He has planted geoducks near the 0 foot tidal level (*) in bays in south Puget Sound and in Willapa Bay. So far his results have been very encouraging. He has employed several methods of culture, ranging from planting geoduck seed directly on the beach and covering with plastic netting, to planting in plastic pools (4 foot diameter by 1 foot deep) filled with clean sand and covered with plastic netting. In the open plantings he is getting survival of 10 to 20%. In the pools he is observing 50 to 70% survival. These young geoducks are growing very fast: planted in July averaging 8 mm shell length, by the end of September they averaged 20 mm.

(*) Editor's Note : The 0 foot tide level in Washington State is the mean lower water level while the 0 foot tide level in B.C. is a level below which the tide rarely falls, called datum.

In terms of an economic analysis, I would guess that when it is commercially available, geoduck seed will cost 2 to 4 times the price of Manila seed, or about $10 to $20 US per thousand. Planting at 30 seed per square meter, one million clams will cover about 8 acres. Assuming a survival rate of 10%, and normal growth rates, 100,000 clams averaging 1.8 pounds each will be available for harvest five years after planting. Harvest costs should be about $0.22 US per pound. At a wholesale value of $1.25 US, and after subtracting seed and harvesting costs, the net value of the harvest comes out at about $165,000 US. Intertidal or nearshore subtidal aquaculture of geoducks has application on sandy muddy bottoms in areas of good currents and high productivity.

SUMMARY AND CONCLUSIONS

Sand substrate nurseries have use for other animals than geoducks. The Lummi Indian Aquaculture facility just put a sand substrate nursery on line for Manila clams. Tradewinds Inc. is using sand substrate raceways for conch culture in the Caribbean. A major advantage of this type of nursery is the lack of labor involved. Whereas animals in upwells require routine cleaning, this kind of maintenance is not required for sand substrate nurseries. Capital investment is probably higher for sand substrate raceways, however, due to the lower labor requirements, they may be more economical to operate in the long haul.

The demonstrated technology of producing geoduck seed opens up the door for geoduck culture, either subtidal or intertidal. Areas which have no geoducks may now well support them if they are planted there. A very basic cost analysis indicates the financial feasibility for geoduck culture.

Question : At what size do geoducks lose the ability to dig?

I don't know. They can still dig well at one year.

Question : Do you have any seed available for the public?

No. We make some seed available on a limited basis for research; however since D.N.R. funds all of the hatchery work, they are the ones who have the final decision on who gets what and for how much. We have given some seed for bioassay work, and some to individuals for intertidal experimental planting. Two of these are Dr. Randy Shuman, who I mentioned earlier, and Mr. Don Rogers, who is developing methods for holding juvenile geoducks in intertidal trays. We have agreements with these individuals for free access to any information they gain from their experiments. One aspect of our current project is to gain the ability to successfully over-winter seed for fall planting, so we are hoping to take advantage of Mr. Rogers' and Dr. Shuman's experiences in designing our over-wintering facilities.

Question : Why are the geoducks from B.C. such high quality with very white necks and those from Washington so poor and dark?

I am not aware of those differences exactly, but Mr. Lynn Goodwin has

told me that in general younger geoducks have whiter necks, but sometimes color is environmentally related. He has just published a paper relating size and quality to geographical latitude and depth. I know that the geoducks we were using for broodstock two years ago, which were from north Puget Sound, were whiter and larger than the broodstock we got last year from south Puget Sound.

Question : Why are the geoduck experiments doing so well at the 0 foot tidal level? I thought geoducks only existed at the lower tidal levels and subtidally?

That is a good question. Previously, based on the experience of recreational diggers, we had assumed that to get geoducks, we needed an extremely low tide. Since Dr. Randy Shuman is having such good success with geoduck seed at the 0 foot tide level, we are thinking that perhaps the reason that we normally don't find them there is not that they can't survive there, but only that they don't recruit there, or don't survive well during the first year. Based on our subtidal planting studies, we have observed that one year old geoducks have buried themselves deep enough to be out of the zone of predation. Thus, at the 0 foot tidal level, geoduck seed that is protected for one year, might well be able to grow to full size and be harvested from an environment where they might not naturally be found.

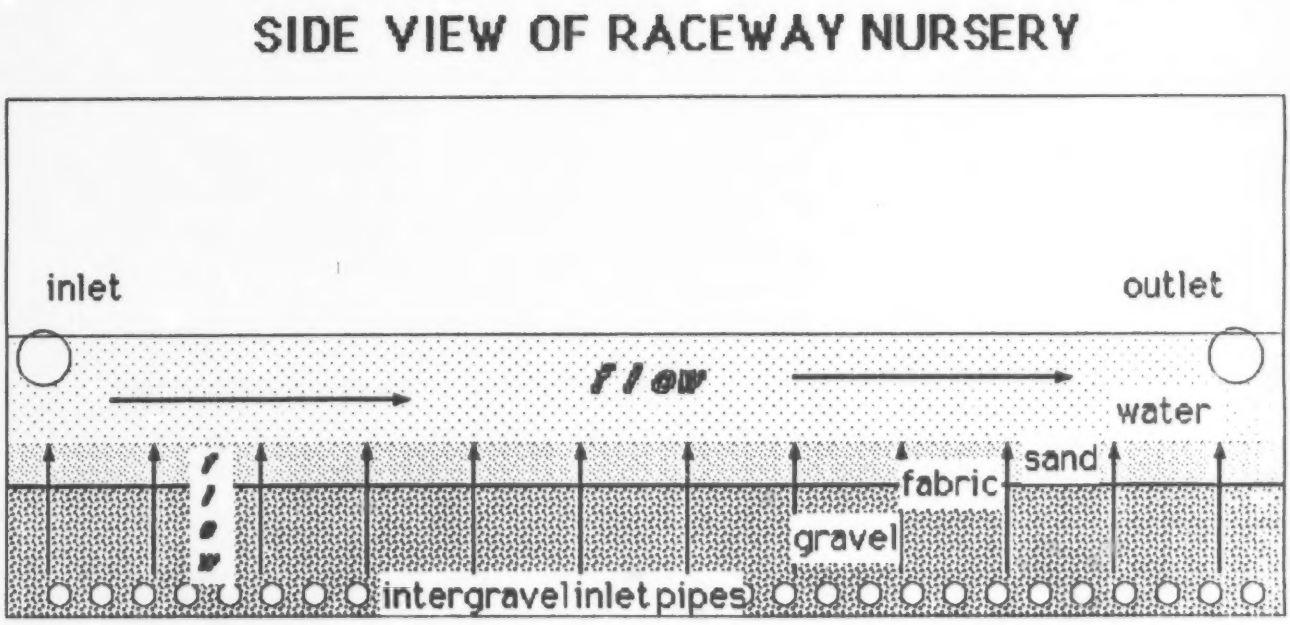


Figure 72: Configuration of the Point Whitney geoduck nursery.

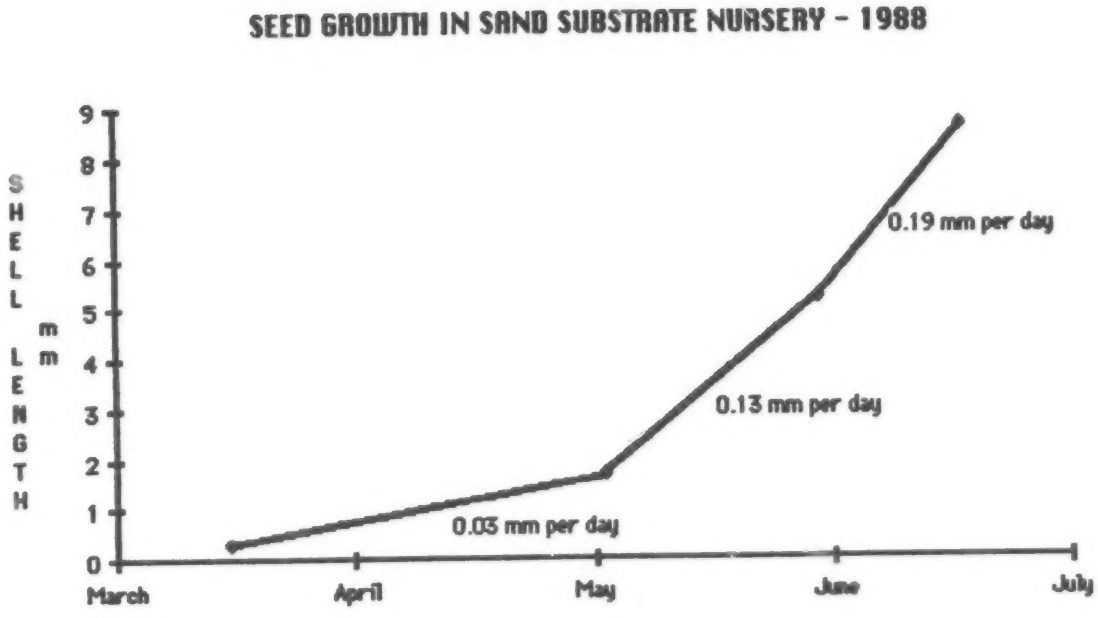


Figure 73: Shell length of geoduck seed over time.

WASHINGTON STATE CLAM FARMER'S EXPERIENCE

Mr. Paul Taylor, Taylor United Inc.

The operations of Taylor United Inc. are located in Southern Puget Sound. Most of our clam production comes from Oakland Bay, which is near Shelton, Washington.

To culture clams, you have to identify possible problems in the proposed culture area. First, look for clams in the beach. If clams are present, culturing is usually more successful. The area to be cultured should be in the normal tidal range of the clam. In the South Sound, this usually would be between a 0 and a 6 foot tide level (*). However, in ideal ground, I have seen clams grow to a 5 foot minus. Another thing to look for is wind exposure. Some beaches get swept by wind and waves. If this happens, the beach will shift too much to grow clams. Currents are normally beneficial because they keep the substrate washed clean, which in turn promotes natural setting. Where the currents are extreme, the ground can reef and shift making clam growing impossible. The above problems are characteristics that are hard to change.

Characteristics that can be changed would include substrate enhancement and predators. Predators that consume clams are crabs, moonsnails, fish and ducks. There is probably a host of others that are not as easy to recognize.

Clams like substrate that is firm, a gravel-shell mixture is their ideal habitat. Clams will grow well in straight gravel substrate, but with shell mixed in, natural recruitment is better. I don't know if clams are attracted to the calcium in the shell or if the ground is less dense, making it a better habitat for small clams.

We have done some work enhancing beaches. Most of our beach enhancement has been done on firm mud or sand bottoms in areas that get a good natural recruitment of clams. The materials we use for enhancement are crushed Pacific oyster shell or gravel. Shell is hard to get in most cases. Fortunately for us, we have an oyster processing plant. Any shell that is not used for oyster cultch is run through a roll crusher that smashes it into pieces that are no larger than an inch square. The gravel, which must be washed, is purchased from a local gravel operation. After the desired material is at the beach head, it is loaded onto a power scow. We then go to the area that needs enhancement (when the tide is in) and spread the material off using a fire hose. One thing to remember when enhancing ground is don't spread the material thicker than an inch at a time. If thick layers are spread, the living organisms in the ground will die, causing the ground to turn black and making it unsuitable for clams for several years. If more than an inch of material is needed on the ground, spread it an inch at a time at 6 month intervals. We put 3 inches of material on most of the ground we have enhanced. Soft bottoms that require lots of material are, in most cases, not economically feasible to enhance.

(*) Editor's Note : The 0 foot tide level in Washington State is the mean lower water level while the 0 foot tide level

in B.C. is a level below which the tide rarely falls, called datum.

Here are some of the costs of ground enhancement that you need to consider. Shell, if you are fortunate enough to get it, cost $25 (**) per cubic yard. Gravel costs $3.00 - $8.00 per cubic yard. Remember, this must be washed gravel. I have been using 5/8 minus gravel because I can get it cheaper than the more desirable 3/4 to 3/8 size. You have to add trucking costs, unless the gravel pit is located on the water. Trucking usually runs between $2.00 and $10.00 per cubic yard. For loading the material on the power scow and hosing it off, the costs are $5.00 to $10.00 per cubic yard. As you can see, there are a lot of variables to look at. For enhancing an acre of ground with 1 inch of material, the costs could vary from $1,300 to $3,640 per acre.

Approximately 60-70% of our clam production comes from artificial ground. Most of it was made between 1900-1925 for the Olympia oyster, as Mr. Doug Magoon was saying earlier. At that time, gravel was taken from the beach to create terraces for the Olympias. There are now laws prohibiting gravel removal from the beaches. The Olympia oyster went into decline because of pollution from a pulp mill in Shelton. Afterwards, the Manila clam was introduced. Being a hardier species, it has taken over some of the oyster beds and has done quite well. Actually, we can grow the Olympia oyster now, but the clams are more beneficial (the pulp mill has since closed down).

Question : Do you grow Olympia oysters?

Yes, I suppose for nostalgia mainly. It is nice to keep the Olympia oyster around and we do harvest some. The economics are not good because it takes 3-4 years for an Olympia oyster to grow.

Predator control. I started putting car covers out about 5 years ago to keep the black scooter ducks from eating the clams. There are several ways to hold car cover on the beach. The surest is to bury the edges under about 4-6 inches of material. This eliminates all predators from coming underneath the net. You still can get predators like crabs and moonsnails that will get through the mesh when they are small and then grow up under it. Another way to put car cover out on the beach is to roll it out and stake the edges down with wooden stakes. This keeps the ducks out; crabs and moonsnails can still go underneath whenever the tide is in.

The method I use to put out car cover consists of tying lead line around all the edges of a piece of car cover. Then, I stake the edges. The lead line enables you to keep the car cover stretched flat on the beach surface. Moonsnails and crabs cannot crawl underneath the edges unless they burrow under the ground, which they don't do very often. The car cover is easy to take off when you harvest and is easy to put back. If you don't get it back down right when you harvest, it doesn't float away.

(**) Editor's Note : Unless specified, all costs are in US funds for this presentation.

Question : Have you buried the edges of your car cover much?

I have trenched some of the edges in; but, on a large scale it doesn't work very well. When you have successive pieces of car cover there is nowhere to put the material from the trench unless you leave a gap between pieces. With lead line around the car cover, one line of stakes can be used for two tarps when the tarps are used in succession.

I buy my car cover from Internet, Inc. (Internet Inc., 2730 Nevada Ave. N., Minneapolis, MN 55427 tel. 612-541-9690 or 800-328-8456). I buy rolls that are 17' wide by 5,000' long. Then, I have it cut into 100' lengths and lead line tied around it. This works well for fill in work around our plant. When the workers have a tarp complete, they roll it on a 1" x 6" board. Then I take it out to the beach. Two people, if they are good workers, can put out 40-50 tarps on a tide.

The cost for car cover, with lead line, is as follows. The lead line (234') to go around a 100' x 17' piece of car cover (50 lb. per 100 fathoms) costs about $20.00. If the beach gets a lot of wave action, 65-80 lbs. per 100 fathoms might be a better weight lead line to use. I use a wide mesh (3/4" x 5/8" mesh) for the car cover. This larger mesh helps prevent siltation. To tie the lead line onto the mesh, I use nylon string which costs $2.00 per tarp. I tie the lead line to the plastic mesh about every 14-18 inches. The car cover costs $13.00 for a 100' x 17' piece. Each tarp needs 10 stakes (PVC or wooden). The cost is $2.00 per tarp. Cost of the stakes can be cut in half if tarps are used in succession.

Question : Do you use more than one layer of car cover?

No, I only use a single layer.

To cover an acre of ground, it requires 25 of the 17' x 100' tarps. The cost to cover an acre is $1,375. The car cover has other beneficial uses besides keeping the ducks out. It also seems to keep crabs and moonsnails out. Sometimes I find moonsnails that get on top of the car cover and they cannot bury in. It is easy to get them out.

Question : How much benefit does car cover have other than predator control?

It is hard to put a definite figure on the benefits. I do know that normally marginal ground, where I have car covered, now is as good as some of my best areas. This could be because of the huge natural catches in the area though. My feeling is that it does have some seed collecting benefits.

If you have car cover down, and your clams are not thick enough in the beach, you should think about seeding your ground. I don't totally stock beaches with clam seed. Where I have found clam seeding works the best is in areas that have a low recruitment of clams. With the seed

clams you can go through a beach on a yearly basis instead of every 2-3 years. In a lot of areas, you can have 6-8 clams per square foot and it is hardly worth digging. But, if you seed your beach you can retrieve your seeded clams plus the clams that were naturally in the beach.

Since it is expensive to buy clam seed, we have been nurturing our own clam seed up from eyed larvae. Two summers ago, I started a pilot nursery project. Last summer (1988) we expanded it. We are doing the same thing that Mr. Geoff Lindsey is doing. Nursery siting is very critical. We have tried three different locations. We found some areas have larger algae and clams larger than 1 mm will have large mortalities because of the lack of proper sized food. Oakland Bay seems to have the best algae for small clams. Next summer (1989) we are looking to set up our nursery there.

We buy our clam larvae from the Lummi's or from Mr. Lee Hansen at Whiskey Creek. We put the larvae on down well screens. These screens are about 3' in diameter and we put 4 million larvae per screen. Depending on the larvae quality, and the food the larvae are getting, screening the larger clams out can start in 2 days. When the clams hold on a 180 micron screen, they are transferred to an upweller. In the upweller, clams need to be graduated constantly. If you don't, the larger animals eat all the food and the smaller animals starve. We grow the clams in upwellers until they are 3-5 millimeters. At that time, it is best to spread them out on the clam ground or put them in trays or spat bags. We don't float our trays like Mr. John Nickerson does. We put them in stacks and stake them down to the beach. The other way to grow clams up beyond the 3-5 millimeter size is to use a 1/8" spat bag. You saw pictures of Dr. Randy Shuman working with these. I purchase the bags from Mr. Ralph Schley at Norplex, Inc. I put 5,000 of the 3-5 millimeter seed in each bags. Then I have them put in several different situations:

1. on a silty bottom that was stable;

2. on a firm bottom that had water covering it; and

3. on a sandy bottom with shifting sand.

With the sandy bottom experiment, the results were the same as Mr. Geoff Lindsey. I ended up with a big sand sausage. The first two situations worked quite well. I had about a 5% mortality rate in the spring when I wintered the clams.

The clams do well until they reach about 10 mm in the grow out bags. Seed coming out of these bags will vary in size, usually between 5-10 mm. That is the size we normally plant.

That completes this part of my presentation.

Question : How thick do you spread the clam seed?

I plant depending on how many clams are in the ground. If there are not many clams, I plant 60 to the square foot. This is about 600 to the square meter.

Question : Do you grow oysters and clams together and which one makes more money?

Let's take the second part of the question first. Right now, in most of our areas, clams are more profitable. With the whole realm of single oysters, it might be changing. Hopefully, we will be able to grow single oysters and clams together and harvest them on a yearly basis. In some areas, oysters on the ground trap the silt and the clams are smothered. In other areas, oysters stabilize the ground and clams will grow where they don't ordinarily grow. This is usually sandy ground.

Question : Will predators eat clams even if there are oysters on the ground protecting them?

Crabs and ducks will still get to the clams unless the oysters are real thick. They are very vigorous.

Question : How do you pay diggers when they dig in seeded areas and how many pounds come off per acre?

I pay by the pound. I have only been seeding a couple of years on a commercial basis. Some of our better natural catch areas, over a 5 year period, have averaged 30,000 pounds per acre per year.

Question : Do the methods of digging in B.C. get more clams off the ground or the methods you use?

That is kind of a leading question. If you took some commercial diggers who dug the beach right and compared their production to ours, right now it would be a wash. I might get more production n a beach I had car covered. I only have 10% under car cover right now.

Question : What happens when you use car cover over oysters?

They will grow into the car cover and it is a real mess. You have a carpet of oysters.

Question : How do you spread the gravel off evenly?

It's really quite easy. We blow it off the power scow with a fire hose. The water pressure will spray it out 20-25 feet. You go back and forth over a piece of ground several times.

Question : What would happen if you put oysters on top of the car cover?

You would end up with a carpet of oysters. I tried putting car cover over oysters and then putting floats on it. It tangled with the oysters, too.

Question : What kind of crab eats oysters?

I am sure that the small shore crabs do some damage but they are not the major predators. The red rock crab and the dungeness are more tenacious and they can really chew up the clams.

Question : Why does hatchery clam seed grow slower than the natural clam seed and what makes the different colors in the clam shell?

The coloration comes mostly from the environment that the clam is grown in. In a few years, maybe I can tell you more on that. Most of our clam seed originates from Mr. Lee Hansen. I furnish most of the broodstock for him, so maybe it is my fault seed clams don't grow well up here.

Question : Do you think clams can be selected to grow faster?

I have been screening off the fastest growing clams and at the end of the summer (1989) I will have a second generation to spawn. Through selecting the best oysters, we have increased growth in Southern Puget Sound by 15-20%.

Question : Do you have a program set up for picking brood stock?

Not a very sophisticated one right now. We don't have absolute control since we don't have a hatchery. In the future, we would like to be able to computerize a brood stock program. The computer would select the brood stock for it's good characteristics.

Question : Can you reuse car covers?

Oh, yes. I have had car covers out for 5 years. It lasts forever.

Question : Have you tried using a blanket on the beach to dig the clams?

No. From what I have seen of this method, not all of the clams come to the surface. My costs are not that high for digging. I think it would take more time to put out the blanket than it would to pick up the clams.

Question : How thick will clams grow in the ground?

Maximum density is about 60 clams to the square foot. That is three different age classes. If you had 60 clams of one age class, they will stunt.

Question : How much do your diggers earn?

I pay twenty five cents a pound and my diggers average between 300-600 pounds a tide.

PROSPECTUS ON PRESENT CLAM CULTURING TECHNIQUES IN WASHINGTON

Mr. Paul Taylor, Taylor United Inc.

I will now talk about the advantages and disadvantages of harvesting in Washington. We just touched on some of the advantages earlier. I hire diggers whose full time job is digging clams. In general, they must be satisfied with their job because I have a very low turnover of personnel. Most of my diggers have worked for me for 5-6 years. Other advantages are you can take clams off when they reach their maximum growth. In B.C., you have a 1 1/2 inch minimum size limit. So, the clams are often harvested at that size. If the 1 1/2 inch clams were left for 6 more months, they might double in volume. So, in Washington, we can maximize production by the time the clams are harvested. Also, you can harvest according to market demands. In summer months, when the market is slow, I put my diggers in slow digging areas. This time of the year, when the market is strong, I have my diggers in the good digging areas. In the summer I can dig clams that are hard to get to during the winter due to stormy weather. You can rotate diggers to different beaches to take advantage of different tidal levels. And finally, I can keep digging costs low.

For disadvantages, well, I am still trying to think of one.

Here are a few tips on marketing. The smaller shellfish grower does best if he concentrates on growing clams and not marketing. That is the purpose of the processor. If you do decide to market clams some of the things you have to deal with are packaging, temperature controls and health regulations for the plant and storage facilities. Another advantage when selling to the processor is that you get quick money. When selling them to different customers, money is slow coming in and you normally don't get everyone to pay.

The processors in our areas have basically the same markets as your processors. We haven't shipped overseas because of the hassles of language barriers, money barriers and time barriers. We started into the California market about 8 years ago. From there it has spread east. We now ship into Houston, Oklahoma City and Chicago. We have several customers on the east coast that we sell oysters to who would love to get clams, but we don't have enough product. Marketing really is not a problem. The problem is keeping your customers at bay because you don't have all the product they want.

Now, I will give a few of the economics of clam culture. I took the two extremes. First, if you started on a piece of ground, like they are talking about giving you, and there was absolutely nothing on it. I took the maximum costs I gave you earlier of $28.00 (*) a cubic yard. I improved an acre with 3" of materials. This would cost $10,920. Then you seeded the ground. Six to eight millimeter seed, at $6.00 per thousand, would cost $16,000 per acre. This cost is for spreading clams 60 to the square foot or 2,600,000 per acre. Let's figure on a 33% survival rate. The second and third year you spread the same amount of seed as the first year. The car cover to cover the ground would cost $1,375. You would have $60,295 invested before you took one penny off

the ground. By the end of the fifth year, if all your labor was free, you would break even.

The other extreme is if you have an acre of clam ground that grew 30,000 pounds of clams a year without any effort, except to dig them. Clam seeding is economical if there is some natural catch in the ground that you can dig along with the seeded clams.

Question : What do you sell clams for?

Around $1.50 a pound at our plant or delivered to the airport.

Question : What kind of survivals have you been getting on clam seed?

I haven't really been in it long enough to give you a good answer. The last couple of years I have put out about 10-12 million seed, but I don't have the final verdict on it yet. I think seeding during the right time of the year (in my area, May through July) is important. On 6-8 millimeter clam seed, seeded the right time of the year, 50-60% survival is not unreasonable. I am not going to tell you to go ask for a loan on it though.

Question : Does digging the ground kill some of the clams that are left?

If the ground is dug using the proper methods, it is quite low. If the substrate is muddy, you may smother a few. The clams that are left in the ground seem to be invigorated by being dug through.

Question : What do you use to dig your clams with?

We use a short tooth rake (6" tines) with a short handle. We dig in rows rolling the ground back into the area that already has been dug. The wrong way to dig clams is to dig a hole and pile the material out around it.

Question : How deep do you dig?

Four to five inches is the maximum.

Question : How do diggers know where to dig?

I just draw a line on the beach with the heel of my boot and they line up and start digging.

(*) Editor's Note : Unless specified, all costs are in US funds for this presentation.

PROSPECTUS ON PRESENT CLAM CULTURING TECHNIQUES IN WASHINGTON

Mr. Dick Poole, Lummi Indian Band

I think Mr. Paul Taylor was reading over my notes. He went through the costs of bringing a piece of ground which essentially had nothing on it to full production. I came up with almost identical figures working on a separate basis. The total cost would be approximately $19,000 (*) per acre if you planted 50 clams a square foot at a cost of $5.00 per thousand larvae. With a harvest rate of a pound per square foot (60% survival) you would get back $43,000 , but if you only got a half a pound you would only gross $26,000 back. I think starting from scratch and doing it on that basis, given the cost of seed, is a little bit marginal. Putting your money in the bank at 8-10% would probably be a lot less risky.

Question : These costs are for U.S. grounds, without clams, prices and conditions are not the same in Canada. Where would you start?

I don't think you have to go to an area where clams are quite abundant. It doesn't have to be an area that has extensive clam populations and it looks like the province and federal people are not going to allow that anyway. They are going to look very carefully at those sites which have large numbers of animals and maintain those as wild harvest and recreational beaches and so on. I think for clam culture you may be looking at some areas in which you are going to have to do some work on and you have to look at those costs.

Question : Can you plant oysters and clams under the protective net for a dual crop?

You end with a huge mat of everything. The oysters will grow into the net and be impossible to separate.

Question : What about bottom culture versus off bottom culture?

I have gone through those kinds of figures. The difference between bottom culture versus off the bottom is the turnover rate. You get a faster product by lifting them off the ground so that instead of a 3 year cycle, you end up with a year and a half or two year cycle. You can't grow any more by raising them up off the ground. The ground area is the same. If you can get a better return from off bottom culture and make better use of the ground, you can justify off bottom culture.

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TRANSFER OF TECHNOLOGY TO BRITISH COLUMBIA - PROVINCIAL ROLE

Mr. Bill Roland, Ministry of Agriculture & Fisheries

First of all, I want to thank all the speakers and people who showed up at this workshop. My role within the Ministry is to facilitate growth and development of the shellfish industry. This is accomplished through education and technology transfer (that can be workshops like this one, special courses, demonstrations or bringing expertise into B.C.), and to a lesser extent by investigation of problems that are blocking future development of culture for a species.

Effort or money is spent where there is a good development opportunity or an obvious need. Where something needs attention, we can implement one of these methods of problem solving. We have to be responsive to need. We operate best in response to requests from grower associations and to problems that are fairly large scale, or to development projects that will produce employment and economic benefits to the province. We have a Research and Development Committee with the Aquaculture Association of British Columbia and the British Columbia Oyster Growers Association that meets roughly twice a year. We don't give grants or help individual companies with funding, but we can help on a consulting basis in the sense of providing information. Also our effort is spent next year; we do our budgeting in August. If a request from industry needs a substantial amount of money, we need to plan ahead.

For clams, as an example, we held this workshop to identify problems, to get information, ideas, and to see how much interest there was in clam culture. A proceedings from this workshop will be used to assist in formulating recommendations in the areas of policy and technology and development.

TRANSFER OF TECHNOLOGY TO BRITISH COLUMBIA - FEDERAL ROLE

Dr. Neil Bourne, Department of Fisheries and Canada

We have discussed research and development requirements for a day and a half during this workshop. We have all listened to the results of work that has been done in this field. I would like to begin my comments by reiterating the quote from Dr. John Manzi that I made in my opening remarks: "Most techniques for the commercialization of clam culture in the United States have been established for many years, they have only awaited appropriate application".

I think most of us would agree that this statement is correct for British Columbia as well, particularly after having attended this workshop. There will certainly be a few new wrinkles in technology as clam culture develops but the basic technology is there. Further research studies are also needed to make clam culture more efficient and hopefully more profitable. In my opinion, the first thing that should be investigated is whether seeding is necessary or whether yields for a given area can be maximized with good husbandry of natural recruitment.

It will certainly be necessary to demonstrate that clam culture will actually increase production and increase the value of harvest for a given area. It is simply not possible to give people a beach or a piece of a beach that will be their own private domain where only they can dig clams. The individual must show that he/she is doing something to increase production. I believe this can be done with good husbandry of natural recruitment. However, if seeding is necessary, then such questions as what densities of seeding are needed and what are the advantages of using large or small seed will have to be investigated. We have listened to discussions on this latter point this afternoon.

Transfer of technology to get clam farming started is important and I would like to bring a few points to your attention.

There is an Intertidal Sectoral Advisory Committee of which Mr. Glen Hadden is the chairman. This Committee is made up of industry people and it has direct input into Fisheries and formulation of management policies. I can assure you that we in Fisheries listen to the proceedings and suggestions of this Committee. We in Fisheries had meetings on Monday and Tuesday of this week to review proposals from this committee, including those on clam culture, and they were discussed in detail at this meeting. This is one way to initiate technology transfer.

Other methods to encourage technology transfer are through workshops such as this, written publications directed towards the industry and having a demonstration facility where large scale clam farming experiments can be done. Such a demonstration facility would provide an opportunity for industry to go and see what is involved in clam farming and to observe the techniques that are used.

I said in my opening remarks that I am positive about clam farming in British Columbia and I think it can be done successfully. However, I

don't believe it is a panacea for the clam industry and I don't believe it is a scheme to become rich overnight. There is a lot of hard work involved in clam culture. I think that one place where clam culture could get started would be on existing oyster leases and I would suggest we investigate the feasibility of doing this.

Question : I want to ask Dr. Bourne and maybe some of the Americans if it is possible to grow oysters and clams on the same piece of intertidal ground. First of all, clam seed would be planted, covered with netting and left for the first year. Then oyster seed, particularly oysters in trays, would be placed over the same ground. We don't have areas as extensive as 110 acres, most small farmers would have only an acre or a one-half of an acre. Could polyculture be carried out on such a limited area? Would it be possible to remove the netting after the first year and then plant the oysters? I don't know if we have the expertise to do such an experiment. Could we ask the Americans to assist us? I think we should undertake research in this field. Could we do it?

I can respond to that question. We've heard from Mr. Paul Taylor that there are problems with polyculture of oysters and Manila clams. Oysters can cause excessive sedimentation but they may also provide better habitat for clams, so there are pluses and minuses. Polyculture depends on the type of culture system you want to develop. As Mr. Paul Taylor said, they harvest clams over their entire area every year. In polyculture you would probably only be able to harvest clams in the area every two or three years, that is when the oysters are of commercial size. So it will depend on the type of culture system you want to establish. I for one am firmly convinced that polyculture of Pacific oysters and Manila clams is feasible in some areas of British Columbia. As far as doing the actual experiment, we have the expertise. It is not a difficult experiment to conduct and could be carried out quite easily. Our problem is a shortage of resources, we haven't many people in our Shellfish Investigation Unit and our funds are very limited. If we had the resources we could do the experiment very easily.

Question : I would like to ask Dr. Bourne if he thinks the industry could undertake experimental clam culture on their own leases and with their own resources. Could we undertake experimental clam culture to see if it is economically realistic?

First of all, I don't see any problem with the industry undertaking any experiments that they want to do. My comment is that's great, go to it. If you have an oyster lease and you want to undertake experimental clam culture on it, then I imagine the first thing you have to do is see the provincial people and ask them if you can use a portion of your lease for this work. I'm certain that something could be worked out with them as long as it is reasonable. We have to use common sense in such an undertaking and that is the procedure I would encourage. As for the industry carrying out experimental work to determine the economic viability of clam culture, I would support this. I have always believed that industry is much better equipped to investigate the economic viability of many fisheries or culture problems, in this case clam

culture, than government or university researchers. Clam culture has to be economically viable or it isn't worth pursuing and industry is most able to do this. I am certain that some type of clam culture experiment to demonstrate the profitability of clam culture could be worked out between governments and industry.

WORKSHOP WRAP-UP

Mr. Lorne Clayton, IEC Collaborative Marine Research & Development Ltd.

Question : What is the current price for Manila clams?

Well, there is a whole range. For example, in Washington in a farm situation when you have extremely dense planting, diggers may get twenty five cents a pound. In Canada, the diggers in the wild get $0.80, $0.85, up to $1.20 which, a few years ago was devastating. There is the processing cost which is washing, sorting, removing all the undersize and broken clams, packaging, boxing and shipping. There is a range of processing involved. When clams get to the retail market half of that may have to be thrown away because of the spoilage then their prices double again. There are a range of prices depending on the level of processing you have in mind.

Question : Can you tell us the optimum size for a clam farm?

No, but I would suggest that it is the same as oyster and fish farming. Not too many people farm fish in their bathtubs. There is an optimal scale and as an entrepreneur you must make the decision whether you feel it is economically viable or not. A gentleman over here said that before the transient digger situation, he made what he thought was a reasonable living at clam digging and that was at $0.80 a pound.

Question : Is there a clam farmers association? Who speaks for clam farmers to get this thing going?

I think there is a requirement for some sort of organizational involvement. I would suggest if people did want to form at least a working group to address these problems with the government or with each other, certainly we have had a gentleman volunteer his time and the Aquaculture Association of British Columbia (A.A.B.C.) would definitely help establish this association. Certainly Mr. Broadley or myself would volunteer our time to assist in this. However, the purpose of this workshop is not to organize an association. (Editors Note : Refer to Appendix VI for information pertaining to the establishment of a Clam Growers/Harvesters Association under the A.A.B.C.)

I have the task of summarizing this two day workshop. I thought there were two different ways I could accomplish this. The first way was to say that the proceedings will be out in four months - so read it - but I guess it requires a bit more than that.

We have had 23 invited speakers at this workshop, not including other people who volunteered their comments. It is much appreciated. I thought I would summarize the points that I feel the speakers made.

Dr. Neil Bourne, in his opening speeches, basically confirmed the fact that in British Columbia we have the environmental capacity to produce a good quality Manila clam product in a reasonable amount of time.

Although the main concern that he pointed out was that we have no idea at this point of the economics of this endeavour and a lot of effort should go into determining if it is an economically viable industry for British Columbia.

Mr. Rick Harbo has suggested that we may have reached our maximum sustainable yields. We certainly had a peak production this last year and with the advent of transient diggers, the industry may be in trouble. Those weren't his words. This is my interpretation. I also got from his talk that clam culture may be a viable alternative and we heard from Ms. Frances Dickson that the federal government is now willing to agree that we should be looking at clam culture in addition to the current fisheries situation.

Mr. Norm Gibbons and Mr. Ron LeBlanc identified a host of problems with the fishery that we have. Over harvesting, size limitations, closures, transient diggers, market flux or volume flux to market. These are all very valid concerns. They also suggested that clam culture in B.C. may be a viable alternative to address some of these problems.

Mr. Rudy Chaing left us with the message that paralytic shellfish poisoning is a problem in British Columbia and diuretic shellfish poisoning (and all the other SP's around) will impact the clam industry, as it does the oyster industry. We must be prepared for that.

Mr. Bruce Kay gave us the same message on bacterial pollution. The problem is not getting any better but it is not getting a lot worse. We have problems with openings and closures and this will affect the potential industry to a large extent.

Ms. Frances Dickson alluded to the fact that the federal government is interested in aquaculture. They have a new Aquaculture Division. She has concerns over sitings of clam farms, what is seeded, what is wild, size limits and the impact of ownership of the resource. These are some of the major problems that must be overcome in Manila clam culture.

Mr. Doug Barry identified that we do have an established framework for getting leases and tenures, the same framework that we have for oyster farming. There are, I believe, about six clam tenures in the province right now.

Mr. Bob Cox expressed the same for the Ministry of Agriculture and Fisheries. There is a Production Plan form being developed. You can register a plan with the province, work through the details with the biologists and come up with a plan to enable you to begin clam culture. People are culturing clams on Lasqueti Island.

Mr. Charlie Twaddle and Mr. Rudy Chaing informed us that there are regulations for processing. They are in place to ensure a good quality, healthy product that we can all be proud of in British Columbia.

Mr. Ray Leitch and Mr. Leigh Loader basically said to us that the market at this point is insatiable for a quality product. We need a consistent supply. Manila clam culture may address these concerns.

Mr. Don Rugg repeated these comments and informed us that given the right proposal the province has some money to assist in product development or in helping people market or develop products for clams and other shellfish species.

Dr. Susan Bower and Dr. Ralph Elston, unfortunately I missed your talks but I will tell you what you said anyway. Clams have various disease concerns, as there are for all species, animals and plants. In British Columbia, we are fairly lucky, we haven't had major problems with disease although in any monoculture system, you eventually get them if the densities are high enough so we must be concerned about that. We must be diligent in making sure that we are not importing contaminated species from around the world. It has happened in many places in the world so while we can afford a growth in the industry, we must be careful of how we go about it.

We have a contingent of people from British Columbia and the United States that are into growing and culturing and hatcheries and nurseries. We see that we can hatch clams and raise them in a nursery. There are methodologies that we can use and we should look at them more closely. Mr. Doug Magoon, Mr. Geoff Lindsey, Mr. John Nickerson, Mr. Dick Poole, Dr. Hal Beattie and Mr. Paul Taylor suggested grow out techniques for clams. Different methodologies for growing clams are available such as trays, gravel, mud, under nets or in bags. It has been done in Washington State. We do not as yet know the economics of clam culture. Obviously if we have natural recruitment involved, the process looks economical but we still have to address that question.

Dr. Neil Bourne and Mr. Bill Roland suggested how we go about transferring the technology. We hold workshops like this, we go, we look and we come back and report. We share information with everybody and the message gets out. They suggested that industry form into a cohesive association before soliciting the government agencies.

In conclusion, I decided I would look at the positives and negatives of where we are. Right now it seems that we have the basic biology. We know some of the environmental requirements but we don't know all the site requirements. We are aware of the basic hatchery, nursery, and grow out technologies. There is an availability of seed. Apparently disease free seed which is nice. We can get a clam lease right now

which is something you couldn't do very long ago. We know that we can process clams and we know we can market clams and we know we can get a good price for B.C. clams.

What are the negatives of where we are today? Well right now we can only get a lease where clams might not grow. I am being a bit facetious, but obviously there is interest in dealing with this issue and there is an opportunity for development in this area. There are size regulations which may limit the economics of culture. Possibly a grower should be able to decide his own harvest size. Once again, we have this problem with ownership versus natural recruitment. We really don't know the best sites for clam farming and the environmental conditions might change yearly. We know nothing about the economics.

I think it is apparent through the interest in this workshop that there is a will and people are interested in pursuing this, hopefully, economically beneficial activity but we require continued cooperation between industry and government. I suggest that the push should be from industry as it gives the people in government the emphasis they need to fund the research that is required. We already have the will, now we have found the way and this is just a starting point.

I would like to thank the speakers from Washington State and California who came up and shared their information with us and all the people who attended. I would like to thank our receptionists, Liane and Tracy and I would like to thank Island Hall for their cooperation. On behalf of the government of British Columbia who sponsored the workshop, AQUAMETRIX who hosted the workshop, Mr. Bill Roland who assisted as government liaison, Mr. Tom Broadley and I thank you for attending this workshop.

APPENDIX I

List of Presenters

Provided is a list of the presenters, in alphabetical order, including their mailing address in order for you to contact them if required.

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APPENDIX II

Suppliers of Clam Culture Equipment

Provided below are the addresses for the suppliers of clam culture equipment mentioned by Mr. John Nickerson in his presentation. Addresses were provided by Mr. Ted Kuiper as a select few suppliers.

Starter Kits:

Ms. Judy Rogers
Olympia Clam Co.,
6331 Murray Crescent NW,
Olympia, WA 98502
(206) 866-9401

Bags:

Mr. Ralph Schely
Norplex Inc.,
7048 South 190th Street,
Kent, WA 98032
(206) 251-6050

Protective Netting:

Internet Inc.
2730 Nevada Ave. N.
Minneapolis, MN 55427
(612) 541-9690 or (800) 328-8456

Trays:

Mr. Randy Shuman
Applied Marine Research,
P.O. Box 51212
Seattle, WA 98115
(206) 523-2702

Seed:

Mr. Ted Kuiper
Kuiper Mariculture Ltd.,
3025 Plunkett Road,
Bayside, CA 95524
(707) 822-9057

Mr. Geoff Lindsey
Canadian Benthic Ltd.,
P.O. Box 97,
Bamfield, British Columbia.
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(604) 728-3274

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APPENDIX III

Clam Bibliography

Presently there is extensive interest within British Columbia to develop an intensive clam culture industry. A major impediment recognized by the industry is the lack of readily available information pertaining to the biology of suitable clam species and appropriate culturing techniques. Although such information does exist, it is widely distributed and not easily accessible by industry.

The primary objective of this Appendix is to present an indexed bibliography of available articles relevant to clam culture. The bibliography has been organized alphabetically by senior author and each cited article has been enumerated for easy referral to the library which has been established at IEC Collaborative Marine Research and Development Ltd. Following each reference is a list of key words. These key words have then been compiled into an alphabetical index. Each key word in the index is followed by the article numbers. This index provides a fast and convenient reference system for specific topics. It is hoped that this bibliography will be of aid to the shellfish industry in British Columbia.

BIBLIOGRAPHY

1. Adachi, K. 1979. Seasonal changes of the protein level in the adductor muscle of the clam, Tapes philippinarum (Adams and Reeve) with reference to the reproductive seasons. Comp. Biochem. Physiol., 64A(1): 85-89.

   Key Words : Proteins; Muscular System; Seasonal Variations; Reproductive Season; Tapes philippinarum

2. Adkins, B.E., R.M. Harbo, N. Bourne. 1983. An evaluation and management considerations of the use of a hydraulic escalator clam harvester on intertidal clam populations in British Columbia. Can. Manuscr. Rep. Fish. Aquat. Sci., No. 1716.

   Key Words : Harvesting; Harvesting Machines; Clam Fisheries; Mortality; Environmental Impact; Management; Saxidomus giganteus; Protothaca staminea; Tapes philippinarum; British Columbia

3.* Anderson, G.J. 1982. Comments on the settlement of Manila clam spat (Tapes philippinarum (Adams and Reeve)) at Filucy Bay, Washington, USA. J. Shellfish Res., 2(1): 115.

   Key Words : Abstract; Spat; Larval Settlement; Population Density; Tapes philippinarum; Filucy Bay, Washington

4. Anderson, G.J., M.B. Miller, K.K Chew. 1982. A guide to Manila clam aquaculture in Puget Sound. Tech. Rep. Wash. Sea Grant.

   Key Words : Biology; Seeding; Harvesting; Substrate; Temperature; Salinity; Stocking Density; Culture; Tapes japonica; Puget Sound, Washington

5. Anderson, G.J., K.K. Chew. 1980. Intertidal culture of the Manila Clam, Tapes japonica, using hatchery-reared seed clams and protective net inclosures. ICES Council Meeting/F:16.

   Key Words : Culture; Predator Control; Seed; Stocking Density; Tapes japonica; Washington

6. Beninger, P.G., A. Lucas. 1984. Seasonal variations in condition, reproductive activity, and gross biochemical composition of two species of adult clam reared in a common habitat: Tapes decussatus L. (Jeffreys) and Tapes philippinarum (Adams and Reeve). J. Exp. Mar. Biol. Ecol., 79(1): 19-37.

Key Words : Body Conditions; Reproductive Activity; Biochemical Composition; Seasonal Variations; Tapes decussatus; Tapes philippinarum; France

7. Beninger, P.G. 1984. Seasonal variations of the major lipid classes in relation to the reproductive activity of two species of clams raised in a common habitat: Tapes decussatus L. (Jeffreys, 1863) and T. philippinarum (Adams and Reeve, 1850). J. Exp. Mar. Biol. Ecol., 79(1): 79-90.

Key Words : Lipids; Bioenergetics; Seasonal Variations; Reproductive Activity; Tapes decussatus; Tapes philippinarum;

8. Boulding, E.G., T.K. Hay. 1984. Crab response to prey density can result in density-dependent mortality of clams. Can. J. Fish. Aquat. Sci., 4(3): 521-525.

Key Words : Predation; Mortality; Survival; Density Dependence; Feeding Behaviour; Cancer productus; Protothaca staminea

9. Bourne, N. 1984. Clam predation by scoter ducks in the Strait of Georgia, British Columbia, Canada. Can. Tech. Rep. Fish. Aquat. Sci., No. 1331.

Key Words : Predation; Aquatic Birds; Melanitta deglandi; Melanitta perspicillata; Melanitta nigra; Protothaca staminea; Tapes philippinarum; Strait of Georgia, British Columbia

10. Bourne, N., S. Farlinger. 1982. Clam survey, Clayoquot Sound, British Columbia - 1980. Can. Manuscr. Rep. Fish. Aquat. Sci., No. 1634.

Key Words : Population Characteristics; Potential Yield; Clam Fisheries; Fishery Surveys; Protothaca staminea; Saxidomus giganteus; Tapes philippinarum; Clayoquot Sound, British Columbia

11. Bourne, N. 1982. Distribution, reproduction, and growth of Manila clam, Tapes philippinarum (Adams and Reeves), in British Columbia. J. Shellfish Res. 2(1): 47-54.

Key Words : Culture; Growth; Reproduction; Tapes philippinarum; British Columbia

12. Bourne, N., B. Adkins. 1985. Savary Island clam study. Can. Manuscr. Rep. Fish. Aquat. Sci., No. 1848: 69-95.

Key Words : Fishery Surveys; Management; Stock Assessment; Protothaca staminea; Tapes philippinarum; Savary Island, British Columbia

13. Bower, S.M., R. Harbo, B. Adkins, N. Bourne. 1986. Investigation of Manila clam (Tapes philippinarum) mortalities during the spring of 1985 in the Strait of Georgia, with a detailed study of the problem on Savary Island, British columbia. Can. Tech. Rep. Fish. Aquat. Sci., No. 1444.

Key Words : Mortality; Habitat; Etiology; Environment; Tapes philippinarum; Savary Island, British Columbia

14. Breen, P.A. 1978. Selective feeding of the Sunflower Star, Pycnopodia helianthoides, in the laboratory. Fish. Mar. Serv. Manuscr. Rep., No. 1498.

Key Words : Feeding; Predation; Population Control; Pycnopodia helianthoides; Strongylocentrotus droebachiensis; Protothaca staminea; Crassostrea gigas; Venerupis japonicus; Saxidomus giganteus; Strongylocentrotus franciscanus

15. Castagna, M. 1986. Clam farming, a U.S. prospective. Virginia Institute of Marine Science.

Key Words : Hatchery; Larvae; Seed; Mortality; Grow Out; Mercenaria mercenaria; US

16.* Chew, K.K. 1977. Manila Clam reseeding prospects in Washington State. Proc. Natl. Shellfish. Assoc., 67: 118.

Key Words : Abstract; Seeding; Stocking; Venerupis japonica; Washington

17. Chew, K.K. 1984. Recent advances in the cultivation of molluscs in the Pacific United States and Canada. Aquaculture, 39(1-4): 69-81.

Key Words : Culture; Venerupis japonica; Venerupis staminea; Mytilus edulis; Haliotis sp.; Patinopecten yessoensis; Patinopecten caurinus; United States; Canada

18. Claus, C., L. Van Holderbeke, H. Maeckelberghe, G. Persoone. 1981. Nursery culturing of bivalve spat in heated seawater. In: Aquaculture in Heated Effluents and Recirculation Systems., Tiews, K., (ed.) 16-17: 465-480.

Key Words : Spat; Culture; Thermal Aquaculture; Experimental culture; Ostrea edulis; Crassostrea gigas; Venerupis semidecussata; Belgium

19. Claus, C., H. Maeckelberghe, N. de Pauw. 1983. Onshore nursery rearing of bivalve molluscs in Belgium. Aquacult. Eng., 2(1): 13-26.

Key Words : Growth; Nursery Ponds; Water Temperature; Feeding; Ostrea edulis; Crassostrea gigas; Venerupis semidecussata; Belgium

20. Claus, C. 1981. Trends in nursery rearing of bivalve molluscs. In: Nursery Culturing of Bivalve Molluscs. Proceedings of the International Workshop On Nursery Culturing of Bivalve Molluscs, Ghent, Belgium, 24-26 Feb. 1981.

Key Words : Culture; Aquaculture Systems; Aquaculture Economics; Seed; Ostrea edulis; Crassostrea gigas; Venerupis semidecussata; Argopecten irradians; Crassostrea virginica

21. Davis, H.C. 1969. Shellfish hatcheries - present and future. Trans. Amer. Fish. Soc., 98(4): 743-750.

Key Words : Hatcheries; Salinities; Feeding; Temperature; Management; Diseases; Crassostrea virginica

22.* Gallager, S.M., R. Mann. 1982. Can phytoplankton carbon/nitrogen ratios be of nutritional significance for bivalves? J. Shellfish Res., 2(1): 96.

Key Words : Abstract; Culture; Diet; Growth; Tapes philippinarum

23. Gallager, S.M., R. Mann. 1981. The effect of varying carbon/nitrogen ratio in the phytoplankter Thalassiosira pseudonana (3H) on its food value to the bivalve Tapes japonica. Aquaculture, 26(1-2): 95-105.

Key Words : Culture; Diet; Growth; Thalassiosira pseudonana; Tapes japonica

24.* Glock, J., E. Hurlbert, P. Becker, M. Kyte. 1979. The development of a management plan for a clam farm in South Puget Sound, Washington. Proc. Natl. Shellfish. Assoc., 69: 203.

Key Words : Abstract; Aquaculture Development; Venerupis japonica; Puget Sound, Washington

25. Glock, J.W., K.K. Chew. 1979. Growth, recovery, and movement of Manila clams, Venerupis japonica (Deshayes) at Squaxin Island, Washington. Proc. Natl. Shellfish. Assoc., 69: 15-20.

Key Words : Growth; Stocking; Venerupis japonica; Squaxin Island, Washington

26.* Glock, J. 1978. Squaxin Island Manila clam reseeding studies. Proc. Natl. Shellfish. Assoc., 68: 90.

Key Words : Abstract; Seeding; Aquaculture Development; Venerupis japonica; Squaxin Island, Washington

27.* Glude, J.B. 1967. Management and development of molluscan resources of the Pacific Coast of the USA. Adv. Abstr. Fish. Aquatic Sci. India, 1(4): 86-87.

Key Words : Abstract; Management; Development; Crassostrea gigas; Saxidomus giganteus; Protothaca staminea; Venerupis japonica; Siliqua patula; Tivela stultorum

28. Glude, J.B. 1974. Recent developments in shellfish culture on the U.S. Pacific Coast. NOAA Technical Report, NMFS Circular, 388: 89-95.

Key Words : Aquaculture Development; Culture; Production; Seed; Ostrea lurida; Crassostrea gigas; Siliqua patula; Tivela stultorum; Protothaca staminea; Saxidomus nuttali; Tapes semidecussata

29.* Goodwin, L. 1971. Distribution of subtidal hardshell clams in Puget Sound, Washington. Proc. Natl. Shellfish. Assoc., 62: 4-5.

Key Words : Abstract; Distribution; Saxidomus giganteus; Protothaca staminea; Puget Sound, Washington

30. Goodwin, L. 1978. Pilot clam seed production. Rep. Wash. Dep. Fish.

Key Words : Seeding; Culture; Saxidomus giganteus; Protothaca staminea; Washington

31. Goodwin, L., W. Shaul. 1978. Puget Sound subtidal hardshell clam survey data. Prog. Rep. Wash. Dep. Fish. no. 44.

Key Words : Stock Assessment; Data Collections; Saxidomus giganteus; Protothaca staminea; Tresus capax; Tresus nuttallii; Puget Sound, Washington

32. Holland, D.A., K.K. Chew. 1974. Reproductive cycle of the Manila clam (Venerupis japonica) from Hood Canal. Washington. Proc. Natl. Shellfish. Assoc., 64: 53-58.

Key Words : Reproduction; Seasonal Variations; Venerupis japonica; Hood Canal, Washington

33.* Jones, C., K.K. Chew. 1976. Planting hatchery spawned Manila clams (Venerupis japonica) in Puget Sound beaches. Proc. Natl. Shellfish. Assoc., 65: 8-9.

Key Words : Abstract; Survival; Growth; Stocking; Venerupis japonica; Puget Sound, Washington

34. Laing, I, S.D. Utting, R.W.S. Kilada. 1987. Interactive effect of diet and temperature on the growth of juvenile clams. J. Exp. Mar. Biol. Ecol., 113: 23-38.

Key Words : Algal Diet; Temperature; Growth; Tapes semidecussata; Tapes decussata; Mercenaria mercenaria; Isochrysis aff galbana; Skeletonema costatum; Chaetoceros calcitrans; Chroomonas salina; Thalassiosira pseudonana; Tetraselmis suecica; Phaeodactylum tricornutum; Chlamydomonas coccoides

35. Langton, R.W., J.E. Winter, O.A. Roels. 1977. The effect of ration size on the growth and growth efficiency of the bivalve mollusc Tapes japonica. Aquaculture, 12(4): 283-292.

Key Words : Growth; Food Consumption; Diet; Nutritional Requirements; Balanced Rations; Tapes japonica

36. Le Borgne, Y. 1981. Nursery culturing of postlarvae to further development for bivalve molluscs hatcheries. European Mariculture Society Special Publication no. 7.

Key Words : Hatchery; Survival; Tray Culture; Off Bottom Culture; Postlarvae; Mercenaria mercenaria; Ostrea edulis; Crassostrea gigas

37. Lucas, A. 1977. Culture of the Manila clam (Venerupis semidecussata Reeve) from hatchery-reared spat. In: 3RD Meeting of the ICES Working Group On Mariculture. pp. 317-330.

Key Words : Nursery Ponds; Growth; Culture; Hatcheries; Spat; Off-Bottom Culture; Venerupis semidecussata; France

38. Mann, R. 1977. The effect of substrate particle size on growth of the Manila clam Tapes japonica. In: Bivalve Mollusc Culture In A Waste Recycling Aquaculture System., Publ. by WHOI, pp. 98-114.

Key Words : Environmental Conditions; Growth; Substrate; Nutritional Requirements; Tapes japonica

39. Mann, R. 1979. The effect of temperature on growth, physiology, and gametogenesis in the Manila clam Tapes philippinarum (Adams and Reeve, 1850). J. Exp. Mar. Biol. Ecol., 38(2): 121-133.

Key Words : Temperature; Growth; Physiology; Gametogenesis; Tapes philippinarum

40. Mann, R., J.H. Ryther. 1977. Growth of six species of bivalve molluscs in a waste recycling - aquaculture system., Aquaculture, 11(3): 231-245.

Key Words : Growth; Experimental Culture; Algal Culture; Recirculating Systems; Crassostrea gigas; Tapes japonica; Mercenaria mercenaria; Crassostrea virginca; Mytilus edulis; Ostrea edulis; Phaeodactylum tricornutum

41. Mann, R., R.E. Taylor. 1977. Long term studies of the growth of the Japanese oyster, European oyster and Manila clam in a waste recycling aquaculture system. In: Bivalve Mollusc Culture In a Waste Recycling Aquaculture System. Publ. by WHOI.

Key Words : Experimental Culture; Temperature Effects; Waste Water Aquaculture

42. Mann, R., J.H. Ryther. 1979. Trace contaminant accumulation by organisms grown in a waste recycling aquaculture system. In: Proceedings of the Tenth Annual Meeting. World Mariculture Society, pp. 809-822.

Key Words : Waste Water Aquaculture; Experimental Culture; Algae; Bioaccumulation; Tapes philippinarum; Crassostrea gigas; Ostrea edulis; Humerus americanus; Gracilariopsis sjostedtii; USA

43. Manzi, J.J. 1985. Clam aquaculture. In: Crustacean and Mollusc Aquaculture in the United States. pp. 275-311.

Key Words : Production; Biology; Culture; Diseases; Constraints; Economics; Mya arenaria; Spisula solidissima; Arctica islandica; Mercenaria mercenaria; Tapes japonica; USA

44.* Miller, M., C.D. Magoon, L. Goodwin, C. Jones. 1977. Manila clam reseeding studies in Puget Sound. Proc. Natl. Shellfish. Assoc., 67: 128.

Key Words : Abstract; Seeding; Stocking; Venerupis japonica; Puget Sound, Washington

45.* Miller, M., K. Chew, C.D. Magoon, L. Goodwin, C. Jones. 1978. Preliminary report on Manila clam reseeding program at five Puget Sound beaches. Proc. Natl. Shellfish. Assoc., 68: 91.

Key Words : Abstract; Seeding; Beaches; Feasibility Studies; Venerupis japonica; Puget Sound, Washington

46. Mottet, M.G. 1980. Research problems concerning the culture of clam spat and seed. Wash. Dep. Fish. Tech. Rep. no. 63.

Key Words : Spat; Seed; Larvae; Metamorphosis; Behavior; Ecology; Food Selection; Temperature; Light; Tide; Water Quality; Predation; Stocking; Substrate; Stock Density; Growth; Survival; Grow Out; Mya arenaria; Mercenaria mercenaria; Anadara broughtoni; Anadara granosa; Meretrix lusoria; Meretrix meretrix; Spisula sachalinensis; Venerupis decussata; Venerupis japonica; Venerupis semidecussata; Tapes japonica; Tapes philippinarum; Astropecten irregularis; Asteria amurensis; Urosalpinx cenerea

47.* Nosho, T.Y., K.K Chew. 1971. A preliminary survey into the setting and growth of the manila clam Venerupis japonica. Proc. Natl. Shellfish. Assoc., 61:11.

Key Words : Abstract; Population Surveys; Setting; Growth; Venerupis japonica

48. Nosho, T.Y., K.K. Chew. 1971. The setting and growth of the Manila Clam, Venerupis japonica in Hood Canal, Washington. Proc. Natl. Shellfish. Assoc., 62: 50-58.

Key Words : Setting; Growth; Substrate; Venerupis japonica; Hood Canal, Washington

49. Ovens, C.B. 1982. Clam seeding techniques tested in Northwest commercial operation. Aquaculture Magazine, 8(3): 24-29.

Key Words : Hatchery; Seed; Stocking; Harvesting; Planning; Tray Culture; Long line Culture; Off Bottom Culture; Venerupis japonica; Washington

50. Pearson, W.H., D.L. Woodruff, P.C. Sugarman, B.L. Olla. 1981. Effects of oiled sediment on predation on the Littleneck clam, Protothaca staminea, by the Dungeness crab, Cancer magister. Estuar. Coast. Shelf Sci., 13(4): 445-454.

Key Words : Pollution Effects; Predation; Protothaca staminea; Cancer magister; Washington

51. Peterson, C.H., H.C. Summerson, S.R. Fegley. 1987. Ecological consequences of mechanical harvesting of clams. Fishery Bulletin, 85(2): 281-298.

Key Words : Ecology; Mechanical Harvesting; Mercenaria mercenaria; Argopecten irradians

52. Peterson, C.H., M.L. Quammen. 1982. Siphon nipping: its importance to small fishes and its impact on growth of the bivalve Protothaca staminea (Conrad). J. Exp. Mar. Biol. Ecol., 63(3): 249-268.

Key Words : Growth; Predation; Pisces; Protothaca staminea; Hypsopsetta guttulata; Leptocottus armatus; Paralichthys californicus; California;

53.* Phibbs, P.H. 1971. Temperature, salinity and clam larvae. Proc. Natl. Shellfish. Assoc. 61: 11.

Key Words : Abstract; Temperature; Salinity; Larvae; Protothaca staminea; Tapes semidecussata; Tresus capax

54. Richardson, H. 1985. Availability of buried Littleneck clams (Venerupis japonica) to Northwestern crows (Corvus caurinus). J. Anim. Ecol., 54(2): 443-457.

Key Words : Predation; Body Size; Selective Feeding; Venerupis japonica; Corvus caurinus; British Columbia

55. Richardson, H., N. Verbeek. 1986. Diet selection and optimization by Northwestern crows feeding on Japanese Littleneck clams. Ecology, 67(5): 1219-1226.

Key Words : Energetics; Diet; Selective Feeding; Venerupis japonica; Corvus caurinus

56. Robinson, A.M., W.P. Breese. 1984. Gonadal development and hatchery rearing techniques for the Manila clam Tapes philippinarum (Adams and Reeve). J. Shellfish. Res. 4(2): 161-164.

Key Words : Spawning Season; Hatchery; Salinity; Temperature; Growth; Tapes philippinarum; Washington

57. Robinson, A.M., W.P. Breese. 1982. The spawning season of four species of clams in Oregon. J. Shellfish. Res., 2(1): 55-57.

Key Words : Spawning Season; Reproductive Cycle; Tresus capax; Saxidomus gigantea; Venerupis staminea; Clinocardium nuttallii; Oregon

58. Rodde, K.M., J.B. Sunderlin, O.A. Roels. 1976. Experimental cultivation of Tapes japonica (Deshayes) (Bivalvia: Veneridae) in an artificial upwelling culture system. Aquaculture, 9(3): 203-215.

Key Words : Diet; Spawning; Metamorphosis; Survival Rates; Experimental Culture; Chaetoceros curvisetus; Bellerochea polymorpha; Thalassiosira pseudonana; Tapes japonica

59.* Roels, O.A. 1981. The economics of artificial upwelling mariculture. J. Shellfish. Res. 1(1): 122.

Key Words : Abstract; Culture; Artificial Upwelling; Economics; Tapes japonica

60. Sunderlin, J.B., P.T. Baab, E.M. Patry. 1976. Growth of clam and oyster larvae on different algal diets in a tropical artificial upwelling mariculture system. In: Proceedings of the Seventh Annual Meeting of the World Mariculture Society. pp. 215-228.

Key Words : Experimental Culture; Artificial Upwelling; Diet; Tapes japonica; Ostrea edulis; Crassostrea gigas; Japan

61.* Vanderhorst, J.R., P. Wilkinson. 1978. Clam resource measurement for estimation of pollution damage. Proc. Natl. Shellfish. Assoc., 68: 92.

Key Words : Abstract; Pollution Monitoring; Pollution Effects; Analytical techniques; Protothaca staminea; Washington

62. Villegas, C.T. 1978. Preliminary studies on growth and survival of Penaeus japonicus postlarvae fed with Tapes and commercial formula feeds. Q. Res. Rep. Aquacult. Dep. Southeast Asian Fish. Dev. Cent. 2(1): 1-4.

Key Words : Growth; Feed; Survival; Penaeus japonica

63. Walker, R.L. 1984. Effects of density and sampling time on the growth of the hard clam, Mercenaria mercenaria, planted in predator free cages in coastal Georgia. The Nautilus, 98(3): 114-119.

Key Words : Density; Sampling Time; Growth; Predator Control; Mercenaria Mercenaria; Georgia

64. Walker, R.L. 1983. Feasibility of mariculture of the hard clam Mercenaria mercenaria (Linne) in coastal Georgia. J. Shellfish. Res., 3(2); 169-174.

Key Words : Predator Control; Culture; Mercenaria mercenaria; Georgia

65. Williams, J.G. 1980. Growth and survival in newly settled spat of the Manila clam, Tapes japonica. Fish. Bull., 77(4): 891-900.

Key Words : Spat; Growth; Survival; Larval Settlement; Tapes japonica; Washington

66. Williams, J.G. 1980. The influence of adults on the settlement of spat of the clam, Tapes japonica. J. Mar. Res., 38(4): 729-741.

Key Words : Larval Settlement; Spat; Adults; Tapes japonica; Washington

67. Yap, W.G. 1977. Population biology of the Japanese Littleneck clam, Tapes philippinarum, in Kaneohe Bay, Oahu, Hawaiian Islands. Pacific Science, 31(3): 223-244.

Key Words : Population; Survival; Mortality; Predation; Thalamita Crenata; Tapes philippinarum; Kaneohe Bay, Hawaii

Note : * denotes that only the abstract is currently available.

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APPENDIX IV

Marine Shellfish Farm Development Plan

MARINE SHELLFISH FARM DEVELOPMENT PLAN

Name of Applicant:_____

Address:_____

_____

_____

Postal Code:_____

Telephone:_____(office)

_____(home)

Location of Site:_____

Ministry of Forests and Lands File No._____

Date of "Application for Crown Land":_____

DESCRIPTION OF MARINE SITE

1. Map Reference: Latitude: _____° _____' _____"
   Longitude: _____° _____' _____"
   NTS Map Number: _____:

2. Geographic Description of site (use nearby land/marine features):

   _____

3. Area of site applied for: _____hectare(s).

SITE SUITABILITY

(Contact Ministry of Agriculture and Fisheries for assistance if required)

1. Exposure to winds and waves:

   - maximum fetch _____ nautical miles
   - fetch direction _____ compass direction
   - maximum wave height anticipated: _____ metres
   - prevailing wind direction (direction that winds blow from):
   - spring _____ summer _____ fall _____ winter _____

2. Annual tidal range:
   mean tide _____ metres large tide _____ metres

   Water circulation:
   - average current speed _____ cm/second
   - maximum flow on a spring tide _____ cm/second

3. Annual water temperature at 1 metre: mean _____°C
   minimum _____°C
   maximum _____°C

4. Annual salinity at 1 metre: mean _____°/oo
   minimum _____°/oo
   maximum _____°/oo

5. Identify known predators, pests and fouling organisms in the area (e.g. starfish, crabs, barnacles, mussels, seaweed, etc.) which may effect growth and survival of shellstock: _____

   _____

6. Has the area been surveyed by the federal De artment of Environment for sanitary growing water quality? yes_____ no_____. If yes, indicate the date _____, and the results of the survey as it relates to the site. _____

   _____

7. Are there any actual or potential sources of pollution located nearby which may affect shellstock quality? yes_____ no_____ . If yes, indicate the distance _____km, and identify the source(s), type(s) and quantity of pollutant(s) involved (e.g. sewage, industrial, logging)._____

_____

8. Is the site in a Department of Fisheries and Oceans paralytic shellfish poisoning closure area? yes_____ no_____. If yes, indicate if the closure is year round _____ or seasonal _____.

9. Will any site modifications be necessary: yes_____ no_____ . If yes, see section on "Shellfish Farm Facilities and Layout".

10. If there is no road access, what is the distance, by water, to the nearest:
    (a) road head _____ km
    (b) processing facility _____ km

11. Describe, as applicable, the beach and/or subtidal substrate at the site. Mud/silt _____%, sand _____%, gravel_____%, cobble _____%, rock _____%.

12. Are marine plants present? yes _____ no _____. If yes, indicate types and approximate coverage. Eelgrass _____% sea lettuce _____%, rockweed _____%, other _____%.

OPERATIONAL CHARACTERISTICS

(Contact Ministry of Agriculture and Fisheries for assistance if required)

1. At full production and for each species (where applicable) state the intended growout and harvest strategy.
    (a) Total amount of seed: _____ No. units
    _____ type of unit (e.g. bags, tubes, single)
    (b) Total production hectares (growout) _____ ha.
    (c) Total non-production hectares (seed holding, conditioning area, etc.) _____ ha.
    (d) Total unusable hectares (soft substrate, rocky substrate, too shallow, etc.) _____ ha.
    (e) Total length of longline (near bottom or deep water) _____ metres and/or number of structures (stakes, racks, rafts, etc) _____. Please indicate type of structure.
    (f) Number of trays and/or cultch (shell, tubes, etc.) per metre of longline and/or structure. _____ /m _____ /structure.

2. Seed to be:
   (a) Purchased local supplies _____.
   (b) Produced at own remote set facility _____.
   (c) Imported _____. If seed to be imported indicate origin:
   Country _____ State _____ Hatchery _____
   (d) Collected from Wild Stock: Wild picking permit _____;
   Wild Set collection _____

If more than one source is to be used, please indicate approximate percentage of each:
Purchased _____%, Remote Site _____%, Imported _____%,
Wild _____%

3. Planned Seed Purchase:

	Year	Volume
	____	_____
	____	_____
	____	_____
	____	_____
	____	_____

Seed Units (bags, tubes, singles etc _____

4. On-site Resources

(a) Are there any commercially utilized species of wild stock bivalve shellfish on this site? yes_____ no_____.

(b) If yes, indicate amounts and area per:

Species 1:_____Avg.#/m^2_____Avg.wt./m^2_____Area covered _____m^2

Species 2:_____Avg.#/m^2_____Avg.wt./m^2_____Area covered _____m^2

Species 3:_____Avg.#/m^2_____Avg.wt./m^2_____Area covered _____m^2

c) Person/company doing survey: _____

Phone: _____

d) When was the last date that wild stock bivalve shellfish were commercially harvested from the site? _____ If unknown, contact local Department of Fisheries and Oceans office.

e) If wild and cultured stocks overlap, indicate how cultured stocks will be marked.

Dye (colour and/or type: _____

Paint (colour): _____

Other (please describe): _____

INFORMATION RELATED TO OTHER COASTAL RESOURCE USES

1. The proposed site is in or near (1 km) a designated boat anchorage: yes _____ no _____. (Check marine charts and/or Coast Guard).

2. The site is in or near (1 km) an area used, by recreational boaters for passage, moorage or shore access: yes ____ no ____ unknown _____.

3. The site is used or proposed for log handling or other use (marine or upland): yes _____ no _____ unknown _____. (Information sources: District Forest Office, Regional Lands Office).

4. The site is within 1 km of a coastal marine park or ecological reserve: yes _____ no _____. (Check with B.C. Regional Parks Office, Planning and Ecological Reserves).

5. The site is within 1 km of an Indian Reserve boundary: yes _____ no _____. (Check with Regional Lands Office).

6. The site is within _____ km of the nearest finfish aquaculture facility (sea cages, hatchery, etc).

7. The site is used for commercial fishing (anchoring, seining, trolling, clamming, crabbing, shrimping, etc.): yes ____ no ____ unknown _____. (Check with District Federal Fisheries Office).

8. The site is in or near (1 km) of a known herring spawning area: yes _____ no _____ unknown _____. (Check with District Federal Fisheries Office).

9. A sub-tidal diver survey of the site has been undertaken for the Department of Fisheries and Oceans. yes _____ no _____ N/A _____. (Check with Federal Fisheries District office; see sample of sub-tidal survey form in Shellfish Farm Development Plan Manual).

10. The site (both foreshore and upland) is zoned for shellfish aquaculture: yes _____ no_____. (Check with Regional District Offices). If no, state the current plan and zoning designations (where applicable) _____

_____

11. The site fronts foreshore area of a private upland owner: yes_____ no_____. If yes, state the current use of the upland and foreshore

_____

_____

(Check with Regional Lands Office to determine if the upland owner's consent is required).

NOTE: Attach a map which locates and summarizes the above information.

SHELLFISH FARM FACILITIES AND LAYOUT

Please attach the following maps and diagrams; they should be drawn/drafted in ink, to scale and be consistent with other information in the Development Plan. (Important information requirements and examples of diagrams are provided in the "Introduction" documents).

Location Map and Coastal Resource Uses Map (includes information requested above)

Farm Layout: Include both upland and foreshore uses and facilities. Details of site boundaries, substrate types, tide heights and associated uses (seed holding etc.) should be included where applicable (e.g. bottom, near bottom). Where applicable indicate on what area of the site each species will be cultured. Indicate areas and species where commercially utilized wild stock shellfish are present.

If beach modification is required, show area(s) to be modified and indicate proposed changes in beach profile and substrate composition.

Details of Farm Construction: Where applicable, show details of stakes, racks, near bottom and deep water longlines, rafts, anchoring, systems, etc. (include side and top view diagrams and details of all components). Details are to show the improvementd described in Schedule "A".

Schedule A

Complete a separate schedule "A" for each species cultured.

SCHEDULE A

(Complete a separate Schedule A for each species cultured)

Species cultured _____

SCHEDULE OF IMPROVEMENTS

Description of Improvements	Total Area Covered (m^2 or ha)	Date of Completion

SCHEDULE OF PRODUCTION

Site to be seeded _____ and in full production of
(month, year)

_____ by _____.
(gal./doz.) (month, year)

Proposed Production:	Harvestable Shell Stock Volume (minimum-maximum)	Saleable Seed Units* (minimum-maximum)
Year 1:	_____ to _____ gal/doz.	_____ to _____
Year 2:	_____ to _____ gal/doz.	_____ to _____
Year 3:	_____ to _____ gal/doz.	_____ to _____
Year 4:	_____ to _____ gal/doz.	_____ to _____
Year 5:	_____ to _____ gal/doz.	_____ to _____

*Unit Type: _____

APPENDIX V

Bivalve Shellfish Depuration Information

Bivalve Shellfish Depuration Information

The enclosed shellfish purification pamphlet is an informative handout on the depuration of bivalve molluscs.

A further reference on the mechanics of clam and oyster depuration may be found in the literature in "Clam Depuration Project, Ladysmith, B.C.", Neufeld, Tremblett and Jackson, Technical Report Series of the Industrial Development Branch #83, March, 1975 and "Operation Report: Oyster Depuration Plant, Ladysmith, B.C.", I.H. Devlin, Industrial Development Branch, Fisheries and Marine Service, Environment Canada, December 1971 to May 1972.

Unfortunately, the mechanics of depuration for shellfish species other than native and manila littleneck clams and oysters has not been done. Such experimentation and pilot projects for these species would be required prior to any approval for formal depuration operations.

November 2, 1988

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9. SHELLFISH PURIFICATION

Shellfish harvested from contaminted areas impose a health hazard to the consumer. Shellfish from marginally contaminated areas may, however, cleanse themselves if they are subject to controlled purification processes.

COMPLIANCE:

No shellfish may be taken from closed areas except under the terms of a permit issued for the purpose of purification treatment as specified under a Memorandum of Understanding (MOU) between the applicant and the Department.

Prior to the issuance of any permit, the following conditions must be satisfied:

1) Harvest site acceptability,

2) Approved purification facility and method, and

3) The applicant's acceptance of responsibility for the entire process and committment to maintain control of the product from the time of harvest to the time of release.

Details on the purification program will be described in the sections that follow.

9.1. HARVEST SITE APPROVAL

Each proposed site must first be reviewed and sampled under Departmental supervision to ensure that shellfish harvested from the site will be able to cleanse itself during the purification process. Experience has shown that if the bacterial level in the shellfish is too high, normal purificatin procedures will not reduce the bacterial count to an acceptable level.

Chemicals or other toxic materials are not known to decrease under normal purification procedures. Sites where shellfish do show abnormal levels of chemicals or toxic materials shall not be approved for purification.

COMPLIANCE:

Site Evaluation Criteria:

1) Document review of existing files to determine the cause of the closure. Sanitary survey data shall not show gross pollution conditions. If an update is necessary, on-site inspection to verify the source or potential sources of contamination shall be conducted.

2) Sanitary survey data to show that the bacteriological quality of every water sampling station in those portion of the area exposed to faecal contamination during the worst pollution conditions shall meet the following standard:

   The faecal coliform median MPN of the water not to exceed 88 per 100 ml and not more than 10 percent of the samples to exceed an MPN of 260 per 100 ml for a 5-tube decimal dilution test.

3) On-site sampling of the shellfish for bacterial and chemical contamination will be done under Inspection supervision. Separate samples will be taken at different locations on the beach and at various intertidal levels. The samples will be analyzed individually for bacteriological results to obtain a comprehensive profile of the proposed site. The sample for chemical analysis may be pooled unless there is a reason to suspect non-homogeneity.

4) No shellfish tissue sample shall have a faecal coliform level of 2,300 MPN/100g. If there are any radionuclides, elevated levels of heavy metal, or toxic chemicals, the site shall be rejected.

9.2. TERMS OF A HARVEST PERMIT

Control and verification are the two key elements of a permit system. Both the applicant and the Department must maintain these two elements during the term of the permit. Failure to do so may jeopardize consumer health. If the logistics does not allow the Department to maintain an effective supervision and verification program, no harvest permit shall be issued nor any Memorandum of Understanding signed.

COMPLIANCE:

When a harvest site is found acceptable, for purification purposes, the applicant shall submit a quality control plan specifying the method of harvesting, transportation, and purification. Upon acceptance of the plan and subject to operational capacity of the Department, a Memorandum of Understanding may be signed between the applicant and the Department. The applicant shall submit the name of a master digger who will supervise the digging.

A harvest permit shall specify the following:

1) - the name of the applicant, the name of the master digger if applicable,
   - the location of harvest,
   - the effective date and the expiry date,
   - the purification site.

2) All sacks or containers of shellfish must be properly tagged on site with accurate information on the area, the location, the date, and the name of the digger. In cases where oysters from a single lease or location are delivered in bulk, individual tags can be substituted by a statement signed by the master digger or the permit holder.

3) All shellfish must be delivered directly from the harvest site to purification site under supervision.

4) All the time of harvesting, the permit holder shall erect a sign stating:

"CONTAMINATED AREA HARVESTING"
UNDER PERMIT FOR
PURIFICATION ONLY
PERMIT NO. _____

The sign shall be no less than 0.7 meter wide by 1.0 meter long, and the wordings be visible from a distance of at least 50 meters.

5) The permit holder and the master digger shall have with them, an up-to-date list of diggers showing the name and personal commercial fishing licence number of each digger.

6) The fishery officer responsible for the area of harvest shall be advised each time prior to harvesting.

A Memorandum of Understanding (MOU) shall have provisions for the following specificationsg:

1) The harvest site.

2) The purification site; either the relay site or the depuration plant.

3) The name of the master digger who will represent the applicant in supervising the harvest process on site.

4) The permit holder and the master digger shall have an up-to-date list of the diggers at the harvest site.

5) The method and procedure of gathering and transporting the shellfish from the harvest site to the purification site.

6) The actual purification process and the minimum duration of the process.

7) Quality Control Program: detailing the method and control criteria for the entire operation.

8) Record Keeping: up-to-date, accurate and verifiable records must be kept at the plant on:

- the harvest data: area, location and date of harvest, the tags for each sack must be maintained on file;

- the production record: quantity, lot number, date and time of commencement and completion of processing;

- quality control data: observations and comments, analytical results, and record of verification;

- sales record: the area, the lot number (which will allow the product origin and the production to be traced), the lot size, the shipping date and the name and address of the purchaser.

All records must be kept on file for a minimum of one full year.

9) Subject to Release:

All shellfish harvested under the MOU must remain under detention pending release by the Department.

10) The Effective and Expiry date of the Agreement.

11) Provision to cancel the Agreement and all permits on in the event of non-compliance.

9.3 TYPES OF PURIFICATION

Purification describes the natural process of the shellfish to biologically cleanse itself when it filter feeds in sanitary water. The rate of purification is dependent on the physiological state of the shellfish and the water quality (temperature, salinity, dissolved oxygen, etc.) in which the shellfish is held.

There are two basic categories of purification:

1) Relaying - purification under natural environment.

2) Depuration (controlled purification) - purification in a controlled environment.

9.3.1 RELAYING

A process where live shellfish from a contaminated site are transferred to an approved area to allow biological self-cleansing under natural environment.

9.3.1.1 THE RELAYING SITE

COMPLIANCE:

The site must be located in an approved area. Documentation or on-site review is recommended to ensure that there is no recognizable non-point source (e.g. boat anchorage) of pollution.

The water temperature should not be too cold (minimum of +5 degrees C) or the salinity difference too great (+ or -20%) from the harvest site. The shellfish should be submerged in sufficient depth to reduce the chances of surface contamination or the interruption of the cleansing process at low tides.

The topology of the subtidal beaches may also influence the ability of the shellfish to purify itself. Shallow basins are likely to frequently expose the shellfish during low tides which may increase the chances of surface contamination and also interrupts the cleansing process.

9.3.1.2 METHODOLOGY AND EQUIPMENT

When specifying the method and the equipment used for the relaying process, consideration should be given to the following:

- Whether it is beach relaying or container relaying, the method proposed must allow for the proper cleansing of the shellfish during a specified time period.

- Trays, containers or other equipment used for holding the shellfish must be designed to maximize water circulation and allow equal exposure of all shellfish, and be made of inert material. Packing the shellstock in sacks will restrict water circulation and,

- There must be provision made to allow easy recognition of lot identity.

- Adequate provision must be made for the rapid transfer of purified shellfish to the processing plant without exposure to further contamination.

9.3.2 DEPURATION (CONTROLLED PURIFICATION)

Depuration is a process of cleansing shellfish in a controlled environment. Mr. Santo Furfari has prepared a protocol on this subject as a Proposal For Addition to Part II of the (N. S.S.P.) Manual - "APPENDIX D - CONTROLLED PURIFICATION". Most of the following parameters are taken from his proposal:

9.3.2.1 PLANT SITE

While site selection is a corporate decision, it is advisable to consider the following factors:

- Sea water quality at the site - are there any problems with silt, suspended matter, pH, salinity, or seasonal fluctuations of water temperature.

- Adequacy of potable water supply, electricity, waste disposal services or sites.

- The distance to the harvest sites and proximity to major highways or transportation systems.

- The presence of potential pollution sources such as waste treatment plants or outfalls.

- The effluent discharged should not alter the water quality of the receiving environment.

9.3.2.2 PLANT DESIGN AND CONSTRUCTION

COMPLIANCE:

In addition to meeting the constructional requirements of Schedule I, Parts I and IV of the Fish Inspection Regulations, the plant should be so designed to reduce the chances of cross contamination and the liklihood of allowing contaminated shellfish to bypass the depuration system. Figure (9.1) illustrates an example of a flow-through traffic system.

Since volume and continuity of supply are the basic determinants of economic success in a depuration operation, it is essential to have adequate storage rooms with temperature controls for holding the shellstocks. Since the undepurated shellstocks must not be held in the same room as the depurated product, two or more holding rooms are required.

9.3.3. DEPURATION SYSTEM:

A depuration system shall have an adequate supply of treated seawater. The system must be designed to allow all shellfish to receive the same quantity and quality of the treated seawater.

9.3.3.1 SEAWATER QUALITY

COMPLIANCE:

- Bacteriological compliance: Total Coliform $\leq$2 MPN/100 ml.
- pH at 7.0 to 8.4
- Salinity: Within + or -20% of the salinity of the harvest area (in parts per thousand).
- Dissolved oxygen: minimum level of 5.0 mg/liter (i.e. 5.0 ppm).
- Chemical: free from unacceptable levels of trace metals, organic contaminants or toxic material that would inhibit the physiological activity of the shellstock or would otherwise constitute a health hazard to the consumer.
- Temperature: must be within the range where the shellfish will pump actively.

9.3.3.2 SEAWATER INTAKE SYSTEM:

The system design and the pipe size will vary depending on the needs of the plant. The intake pipe should not be located in close proximity to the discharge pipe. Piping material must be non-toxic, inert and non-corrodible. The pipe size should be sufficiently large to provide adequate volume of seawater to the depuration tanks. Past experience has suggested a flow rate ranging from 3 to 5 litres per minute for each 25 kg (0.5 to 1.0 gallon per minute for each 50 lbs.) of hardshell clams or oysters. A flow equipped with a continuous recorder must be installed at a strategic location along the water line to measure the flow rate.

9.3.3.3 SEAWATER TREATMENT

- Sterilization: the most commonly used system is an ultraviolet light irradiation unit with an automatic water shut-off if the U.V. radiation is not detected by the photo sensor. Continuous sterilization is mandatory in order to ensure that intermittent pollution of the incoming seawater will not re-contaminate the product. The seawater must be treated immediately prior to entering the depuration tanks to avoid possible re-introduction of contamination.
- Filtration: water turbidity will greatly reduce the effectiveness of the U.V. treatment. A proper filtration system will remove particulates and other macroscopic material.

- Aeration: insufficient oxygen content in the water will inhibit the physiological activity of the shellfish. Aeration can be achieved by means of spray discharging of the water or by bubbling compressed air into the tank.

- Heating: If depuration continues in the winter months when the water temperature is near the freezing point, provision to warm the water will be necessary. Heat exchangers could be used for warming the water.

9.3.4 TANK AND BASKET DESIGN:

The tanks and baskets shall be constructed of sturdy, inert and impervious material to facilitate easy cleaning. The tank and basket design must:

- assure uniform hydraulic flow throughout the system so that every shellfish will receive the same quantity and quality of water;

- allow proper stacking and removal of baskets without causing dead pockets in the hydraulic system;

- prevent vibrations or other disturbances which might affect the activity of the shellfish.

COMPLIANCE (Guideline):

Experience has indicated that the following dimensions may be adequate:

- Rectangular tanks: maximum length to width ratio of 4 to 1.

- Depth: maximum of 1 meter (36 inches) to accommodate not more than 4 layers of baskets or containers. The minimum spacing between baskets should be at least 8 cm (3 inches) all around.

- Bottom slope: the bottom of the tank should be sloped to drain at a minimum rate of 2 cm per meter (1/4 inch per foot) to allow easy cleaning.

- Minimum process seawater capacity to overflow level:

  0.15 cubic meter per 25 kg (5 cu. ft. per 50 lbs) for soft shell clams

  0.25 cubic meter per 25 kg (8 cu. ft per 50 lbs) for hard shell clams and oysters

  for baskets, a maximum depth of 8 cm (3 inches) for oysters and hard shell clams; 20 cm (8 inches) for soft shell clams.

9.3.5 OPERATIONAL REQUIREMENTS

Good operational practices will maximize product quality and minimize product loss. Product scheduling, proper storage facilities, initial washing and culling of the shellstocks prior to depuration will help to maximize return.

Regular tank and basket clean-ups and disinfection will prevent the introduction of bacteria during the depuration process.

COMPLIANCE:

In addition to the requirements of Schedule II, Parts I and IV of the Fish Inspection Reulations, the following operational schedules must be observed:

9.3.5.1 STORAGE OF SHELLSTOCKS

Shellfish awaiting depuration must be kept cool to minimize product lost due to mortality.

Incoming shellstocks must not be stored in the same cooler as the depurated product in order to avoid possible cross contamination or the accidental mixing of the two lots.

9.3.5.2 WASHING AND CULLING:

The shellfish must be adequately rinsed with pressurized treated water to remove sand and dirt prior to depuration. Visual culling should also be conducted at the same time to remove any damaged, gaping, or dead shellstocks.

9.3.5.3 TANK CLEANUP AFTER 24 HOURS:

Each depuration tank must be cleaned and disinfected after the first 24 hurs of depuration. This shall be done with the removal of all baskets from the tank. Care must be exercised to avoid re-contaminating the shellfish during loading and unloading.

9.3.5.4 MARKET PREPARATION:

The depurated shellfish must be packed in clean containers. Any broken, gaping or dead shellfish shall be removed.

9.4 SAMPLING AND BACTERIOLOGICAL CRITERIA

GENERAL RULES:

1. One Permit At A Time: Each plant is allowed to harvest in only one contaminated area at any time. This will prevent the possibility of mixing shellstocks from different locations prior to or during depuration.

2. One Lot Per Location Per Day: For the purposes of identification, a lot shall consist of shellfish taken from the same harvest location and destined for depuration on a single day. The size of each lot shall not exceed the maximum daily capacity of the depuration system. Any excess shellfish shall be considered a different lot and subjected to regular sampling.

3. Three Consecutive Acceptable Lots: When the faecal coliform level of incoming shellfish is <50 MPN/100g for each of first three consecutive lots, the requirement of detaining each lot pending bacteriological results may be relaxed at the discretion of the Inspection Supervisor.

4. Representative Sampling: To obtain a bacteriological profile of a lot, the sample must be taken UNIFORMLY from the lot. Unlike random sampling where it is possible to take all the required units from a single sack within a lot, a representative sample should be comprised of units from a cross section of sacks.

9.4.1 SITE APPROVAL

COMPLIANCE:

The water quality must meet the standard prescribed under Section 9:1 of the manual. At least three separate samples shall be taken from each proposed harvest site. The sampling locations shall be determined by the Inspection Officer who would supervise the pre-sampling program.

If none of the samples show a faecal coliform level of >2,300 MPN/100g, the site may be approved provided that it meets all other criteria of site evaluation.

9.4.2 PRE-DEPURATION:

- A representative sample will be taken prior to depuration. This pre-depuration sample may be taken at any time as soon as a lot number has been assigned.

- If the result is ≤2,300 F.C., depuration may proceed or continue; if it is >2,300 F.C., the lot is rejected and the entire shipment must be returned to the beach. Past experience has shown that shellfish with high bacterial level will not depurate properly.

9.4.3 POST DEPURATION:

- All shipments must be detained until the bacteriological result of the post depuration sample is found satisfactory.

- A minimum of one sample shall be taken from each tank at the end of the depuration process (except as per 9.4.4)

- If the result of the final product has F.C. level of:

  ≤50 MPN/100g, the lot may be released.

  >50 and ≤170 MPN/100g with less than 10% of the sample exceeding 130 MPN/100g ,the lot may be released, but all future shipments must be detained.

  any >170 MPN/100g or if 10% or more of the samples exceed 130 MPN/100g, the lot is rejected. All future shipments must be detained. Plant inspection as well as system evaluation will be conducted to ensure that there is no equipment failure.

- In the event that only one sample is taken per lot, the product shall be rejected if the level of F.C. exceeds 170 MPN/100g. All future lots will be detained and system evaluation shall be conducted. If the single sample result is greater than 50 but ≤170 MPN/100g, the sample may be accepted, but future lot will be detained.

- If the results of the post-depuration sample of three consecutive shipments from the same location are all <50 in F.C., the Inspection Suprvisor may at his discretion, waive the detention requirement as outlined in Section 9.4.2.

Figure 9.2 summarizes the above criteria.

9.4.4 REDUCED SAMPLING FOR PROVEN DEPURATION SYSTEMS

At the discretion of the District Inspection Supervisor, a reduced sampling scheme may be implemented if sufficient operational and bacteriological data have been accumulated to establish that the depuration system is indeed fully functional. The reduced sampling scheme should not be opted for prior to the establishment of satisfactory records performance.

OPTIONAL REDUCED SAMPLING SCHEME:

If the F.C. level of the PRE-DEPURATION sample is:

<50	post depuration sample may not be required
>50 - ≤170	1 post depuration sample per lot is required
>170 - <2,300	1 " " " " tank " "
>2,300	the lot is rejected and must therefore be returned to the beach.

- No product may be removed from the depuration tanks until the pre-depuration results are known and recorded.

- Post depuration sample: The criteria are the same as those specified in Section 9.4.3.

9.4.5 SAMPLE SHIPPING

Precautions should be taken during sampling to avoid introducing any contaminants.

The shellfish shall be placed in a new, clean plastic bag which can be sealed or tied to prevent possible cross contamination. Information on the sample, such as lot number, the area and location of harvest, the sampling time and date, as well as the weight of the lot shall be recorded on a sampling form. To prevent the form from getting wet, it can be placed in a plastic bag and tied together with the sample. To help maintain the sample in a cool environment, a frozen gel pack can be placed next to the sample inside the shipping container. The container with the sample should be kept in a cooler up to the time of shipping.

The sample must reach the laboratory in time so that analyses can commence within 24 hours after initial sampling.

9.4.6 BACTERIOLOGICAL ANALYSIS

A protocol on Microbiological Examination of Molluscan Shellfish is found under Appendix 9.

9.4.7 BACTERIOLOGICAL DATA INTERPRETATION

A summary of this subject prepared by Mr. N. Neufeld is attached under Appendix 9.1.

9.5 QUALITY CONTROL PROGRAM

Each processor is responsible for instituting and maintaining a quality control program that meets the approval of the Department.

A quality control program will consist of three functions:

1) QUALITY ASSURANCE - where the objective of the Q.C. program is defined in terms of operational and product standards.

2) PROCESS CONTROL - where action paths for achieving the standards described above may be implemented through proper sanitation procedures and good processing techniques.

3) QUALITY VERIFICATION - where the processor will measure the degree of his goal accomplishment by evaluating the product and the degree of compliance to the process control.

9.5.1 PROGRAM APPROVAL

COMPLIANCE:

The processor must have a well-defined Quality Control Program that is approved by the Department. In addition, it must have the facility and technical expertise to perform the evaluation procedures. Those operators not equipped with laboratory facilities may make arrangements to send the samples to an accredited commercial laboratory.

Any commercial laboratory selected to do the analyses must have a demonstrated capability to perform the analytical procedures specified by the Department and must be prepared to participate in split sample evaluations with the Department upon request. The Department will reserve the right to inspect and evaluate the methodology and all data at any time.

- parallel sampling shall be conducted by Inspection officers from time to time to verify that the depuration process and the accuacy of the analytical data submitted by the commercial laboratory is satisfactory.

9.5.2 RECORD KEEPING

Up-to-date, accurate and verifiable records on the product, the process operation, and the product distribution forms an essential part of the quality verification function. Record ommission or poor record keeping practices are evidences of an unacceptable quality control program.

Production records for purification or depuration must be kept on the following as minimum requirements:

1. Product Control:
   a) The lot number and size.

   b) The harvest location and date.

   c) The name of the master digger or digger.

   d) The bacteriological results of the pre-depuration and post-depuration samples.

   e) The final weight of the depurated product.

   f) The lot number and the distribution of the final product in terms of where, who and when.

2) Operation Control:

   a) The lot number, the batch or tank number of the depuration process, and the quantity in each tank.

   b) "Time-in" and "Time-out" in hour - day - month - year.

   c) The time and duration of the 24 hour tank washdown.

   d) The flow rate chart (continuous recording).

   e) The time when visual inspection of the U.V. system was done to assure functional acceptability. A record of individual U.V. tube in the system shall be kept to ensure that the quartz tubes are replaced when the transparency decreases.

   f) The water temperature, salinity, dissolved oxygen, and turbidity of the water.

   g) Observatins or comments on any process interruption.

9.6 PROGRAM COMPLIANCE VERIFICATION:

Inspection officers will verify the processor's Quality Control Program from time to time. Any deficiencies in the program must be corrected promptly by the processor. Failure to do so or non-compliance to regulatory requirements may result in plant decertification.

9.7 REFERENCES:

1) Devlin, I.H. and Neufeld, N. 1971. Oyster Depuration Plant, Ladysmith, B.C. Fisheries Service, Department of the Environment.

2) Devlin, I.H. 1973. Operation Report: Oyster Depuration Plant, Ladysmith, B.C. Fisheries & Marine Service, Environment Canada.

3) Neufeld, N., Tremblett, A. and Jackson, K. 1975. Clam Depuration Project, Ladysmith, B.C. Fisheries & Marine Service, Environment Canada.

4) Rowell, T.W. et al. 1976. Soft Shell Clam Depuration, Digby, Nova Scotia. Fisheries & Marine Services, Tech Report No. 687, Environment Canada.

5) Furfari, S.A., and Hunt, D.A. 1967. Newburyport, Massachusetts, Plum Island Clam Purification Plant Studies, U.S. Department of Health, Education, and Welfare, Public Health Service Bureau of Disease Prevention and Environmental Control, National Center for Urban and Industrial Health, Water Supply and Sea Resources Program Northeast Marine Health Sciences Laboratory, Narragansett, Rhode Island.

6) Furfari, S.A., Adams, W.N., and Miescier, J.J. 1974. Soft Clam Depuration Plant Studies, Newburyport, Massachusetts, Department of Health, Education, and Welfare, U.S. Public Health Service, Food and Drug Administration, Northeast Technical Services Unit, Davisville, Rhode Island.

7) Furfari, S.A., Miescier, J.J., and Carr, V.E. 1974. Depuration Study - Soft Clams, Highlands, New Jersey, Department of Health, Education, and Welfare, U.S. Public Health Service, Food and Drug Administration, Northeast Technical Services Unit, Davisville, Rhode Island.

8) Miescier, J.J. 1976. Memorandum - Depuration Monitoring Program at Three Soft Clam Purification Plants in Maine, Department of Health, Education, and Welfare, U.S. Public Health Service, Food and Drug Administration, Northeast Technical Services Unit, Davisville, Rhode Island.

9) Furfari, S.A. 1979. Memorandum - Soft Clam Depuration Plant, Searsport, Maine - Additional Data, Department of Health, Education, and Welfare, U.S. Public Health Service, Food and Drug Administration, Northeast Technical Services Unit, Davisville, Rhode Island.

10) Furfari, S.A. 1966. Depuration Plant Design. Environmental Health Series, Food Protection, Public Health Services, U.S. DHEW, PHS 999-FP-7:7.

11) Huntley, B.E. and Hammerstrom, R.J. An Experimental Depuration Plant - Operation and Evaluation. Chesapeake Science Vol. 12, No. 4, p. 231 - 239 December 1971.

12) MacMillan, R.B. and Redman, J.H. Hard Clam Cleansing in New York, Commercial Fisheries Review, Reprint No. 908.

NOTE: The above list is not current.

APPENDIX VI

Aquaculture Association of British Columbia

CLAM GROWER/HARVESTER REPRESENTATION

At present there is no association which specifically addresses the concerns of prospective clam farmers in British Columbia. The Aquaculture Association of British Columbia (A.A.B.C.), however, actively promotes and protects the interests of aquaculturists in the province. The A.A.B.C. is made up of producers, processors, food brokers, educators, suppliers, researchers and interested parties. Its members represent every commodity species farmed in this province. The Board of Directors of the A.A.B.C. has a seat designated to represent the B.C. Oyster Growers Association, the B.C. Salmon Farmers Association and the Western Trout Farmers Association.

In the recent past the Board of Directors has researched, prepared and presented formal papers on issues such as Provincial Sales Tax exemption policy, recommendations to the Gillespie Inquiry on fin fish farming; research and development, the ban on tributyl tin (T.B.T.) for aquaculture use in B.C. and a brief on aquaculture development in B.C. up to 1990 in the province. The A.A.B.C. also publishes a newsletter which keeps members informed on issues and developments around the province.

The A.A.B.C. is helping establish aquaculture as a long term viable industry in B.C. through public awareness and dissemination of information at our seminars and annual general meeting.

We are pleased to offer membership in the A.A.B.C. to those wishing to pursue the potential of clam farming in British Columbia. Your membership in this Association will provide you with a representative voice in the development of the clam farming industry in British Columbia.

For further information on the Aquaculture Association of British Columbia please contact:

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APPENDIX VII

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David Thomson	Neville Seafarms, C19 Site 10 RR 1, Black Creek, B.C. V0R 1C0
Alex Turner	Gorilla Productions Ltd., 919 2nd St., Courtenay, B.C. V9N 1C2
Jan Vandendries	General Delivery, Lasqueti Island, B.C. V0R 2J0
Daniel Viedeau	Box 547, Tofino, B.C. V0R 2Z0
David Vincent	Malaspina College, Aquaculture and Fisheries, 900 5th St., Nanaimo, B.C. V9R 5S5
Grant Webb	Box 161, Manson's Landing, Cortes Island, B.C. V0P 1K0
Otis Weland	OTSC Enterprises, Lasqueti Island, B.C. V0R 2J0
Kim Wilson	Box 3092, Courtenay, B.C. V9N 5N3
Ian Winter	Box 10, Squirrel Cove, B.C. V0P 1T0
Bernard Wohlleben	C4 526 RR 2, Gabriola Island, B.C. V0R 1X0
Dorothy Young	Box 987, Nanaimo, B.C. V9R 5N2
Lori Young	Malaspina College, 319 Kennedy St., Nanaimo, B.C. V9R 2J2